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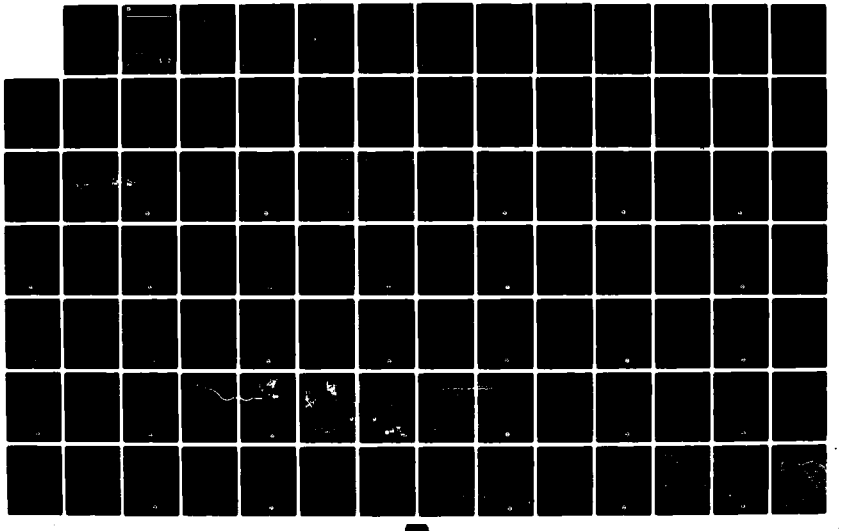

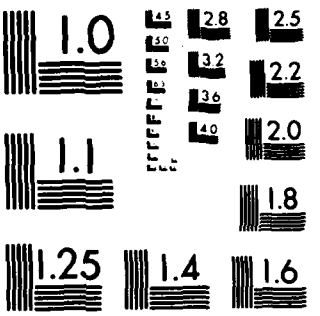

US Army Corps
of Engineers
St. Paul District

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DESIGN MEMORANDUM NO. 3
GENERAL--PROJECT DESIGN
APPENDIX B - GEOLOGY AND SOILS

LAKE DARLING
FLOOD CONTROL PROJECT
SOURIS RIVER, NORTH DAKOTA

JUNE 1983

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Design memorandum #3	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) LAKE DARLING FLOOD CONTROL PROJECT, SOURIS RIVER NORTH DAKOTA: General-project design. Appendix B-Geology and Soils.		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, St. Paul 1135 USPO & Custom House St. Paul, MN 55101		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE June 1983 13. NUMBER OF PAGES 101
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

FLOOD CONTROL
SOURIS RIVER
GEOLOGY
SOILS

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Lake Darling project is the second phase of the total flood control plan for the Souris Valley in North Dakota. Appendix B addresses physiography, geology, ground water, site topography, water table, and plates of the Lake Darling Dam, including stability analysis and borings.

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FLOOD CONTROL
LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

DESIGN MEMORANDUM NO. 3
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APPENDIX B

GEOLOGY AND SOILS

DEPARTMENT OF THE ARMY
St. Paul District Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

FLOOD CONTROL - LAKE DARLING

SOURIS RIVER, NORTH DAKOTA

DESIGN MEMORANDUM NO. 3 - GENERAL

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APPENDIX B

GEOLOGY AND SOILS

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PHYSIOGRAPHY

1. The Souris River basin lies in the Drift Prairie section of the Central Lowland Physiographic province and the Coteau Du Missouri which forms the eastern border of the Great Plains physiographic province. Four major geologic and topographic features are present to further subdivide these major sections. These are the Missouri Escarpment, ground-moraine plain, the lake bed of glacial Lake Souris and the southwest portion of the Turtle Mountain (see Figure 1).

2. The entire length of the Des Lacs River valley and that portion of the Souris River valley upstream from Verendrye are in the area of the ground-moraine plain. Both valleys in this area were cut when the rivers were swollen with glacial meltwater and were subsequently aggraded to their present levels after the glaciers receded from the area. The existing condition in both valleys is, therefore, one of a small stream in an oversized valley. The floor of the Souris River valley lies 100 to 200 feet below the ground-moraire plain, and the valley walls are fairly steep-sided. The presence of short, intermittent drainages that head only a few miles from the river give the valley walls a slightly dendritic form with little or no correlative terrace development. The valley floor averages 3/4-mile in width and forms a relatively flat surface which is broken by a sinous river channel, meander scars and small alluvial fans. The Des Lacs River valley is similar in form to the Souris River valley in the ground-moraine plain. The valley floor averages 1/2-mile in width and is incised up to 275 feet below the surrounding plains.

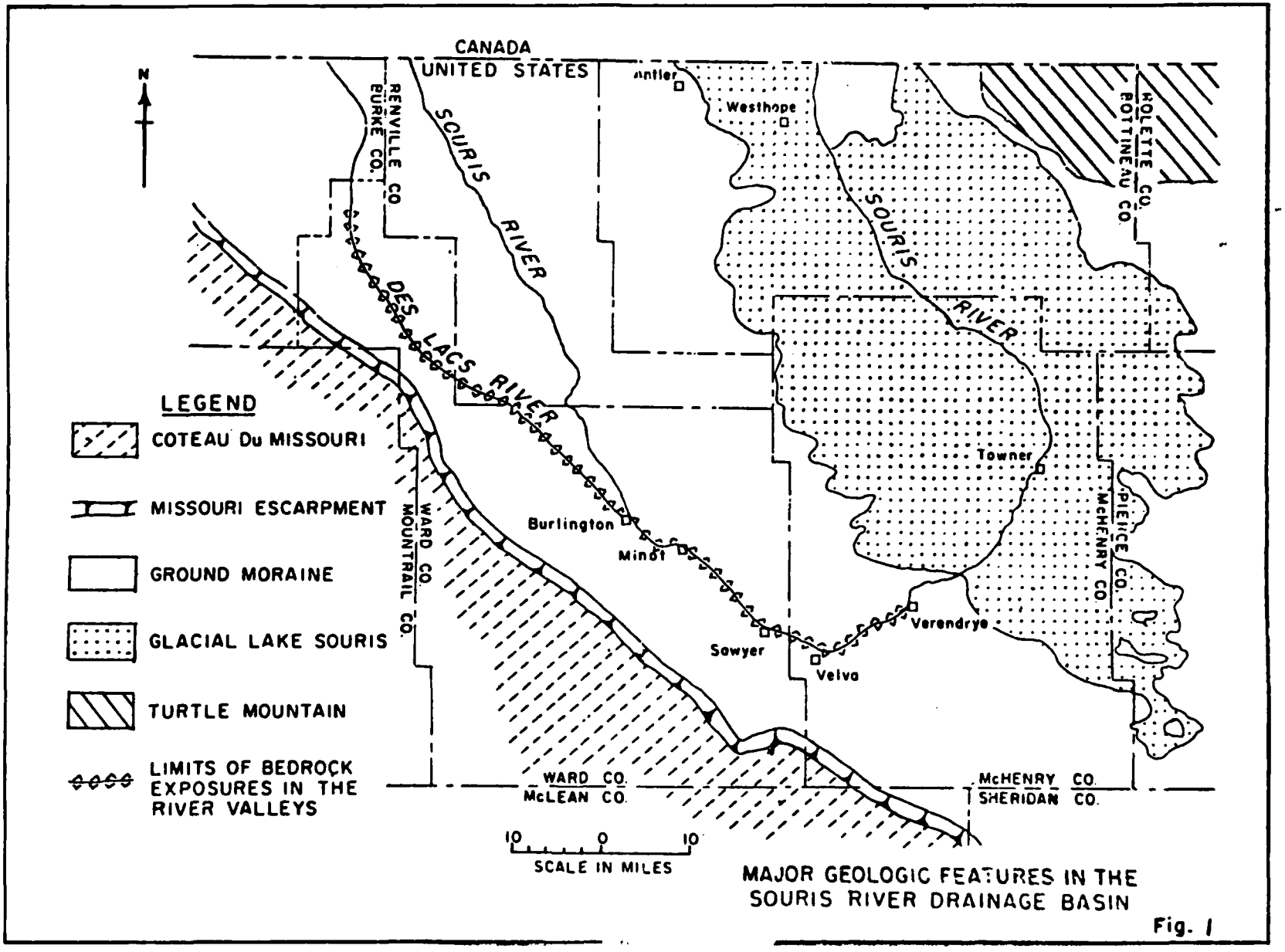
3. The Souris River valley downstream from Verendrye is formed in the glacial Lake Souris area. The valley form in this area varies drastically from that in the ground-moraine plain. The valley is 1/2 to 3 miles wide and is entrenched less than 100 feet below the surrounding plain. In places, a valley form is barely perceptible.

4. Except for the Missouri Escarpment and areas bordering stream valleys, much of the drainage pattern within the Souris River basin varies from poorly defined to noncontributing. Many of the noncontributing areas include numerous small depressions where surface water is trapped.

5. The only naturally wooded areas in the basin exist along drainages, the slopes of the Turtle Mountain, and some duned areas in the Lake Souris area. Elsewhere in the basin, the surface is unwooded except where trees have been planted near dwellings and for windbreaks. The basin is sparsely populated with most of the land surface used for pasture or cultivation.

GENERAL GEOLOGY

6. Glaciers invaded the Souris River basin several times during the Pleistocene Epoch. The most significant invasion was the Mankato Substage of the Wisconsin glaciation which laid down thick deposits of drift that obscured much of the preglacial topography. The valleys of the Souris and Des Lacs Rivers were carved, or enlarged, by great quantities of water supplied by the melting ice and were subsequently filled to their present levels as the flows diminished.



MAJOR GEOLOGIC FEATURES IN THE SOURIS RIVER DRAINAGE BASIN

Fig. 1

7. No sharp demarcation separates Recent from Pleistocene time. After the last retreat of glacial ice, conditions gradually gave way to those existing today. The glacial features have suffered little from erosion so that present topography is composed essentially of unaltered glacial forms. Integrated drainage has not yet been established in much of the basin.

8. Unconsolidated surface deposits in the basin are of two types: recent alluvium and Pleistocene glacial deposits. Recent alluvium comprises only a small portion of the surface materials and consists of clay, silt, fine-to-medium sand with minor amounts of coarse sand, and gravel. Significant alluvial deposits are restricted to the valleys of the Souris and Des Lacs Rivers where they generally exceed 50 feet in thickness. The glacial material consists primarily of morainal deposits and sediments of glacial Lake Souris. Morainal deposits are composed of an impervious, stoney clay till with thin seams, lenses, and channels of sand and gravel. This material occurs under the Coteau Du Missouri with an average thickness of 100 to 200 feet and varies from 50 to 300 feet in thickness throughout the ground-moraine plain and under the sediments of glacial Lake Souris. The till is often absent in the river valleys. Buried preglacial valleys, outwash channels, kames, eskers, overridden ice-contact deposits, river terrace deposits, diversion channels, and undifferentiated glaciofluvial deposits occur throughout the ground-moraine plain and contain a higher sand and gravel content than the glacial till. The deposits of glacial Lake Souris range in thickness from a feather-edge to more than 70 feet. Material in the Lake Souris area is predominantly silt and moderately to poorly graded sand with sand and gravel beach and other near-shore deposits.

9. The bedrock units exposed or forming the buried preglacial erosional surface in the Souris River basin are, in descending order, the Sentinel Butte, Tongue River and Cannonball Formations of the Fort Union Group of the Tertiary System and the Hell Creek and Fox Hills Formations of the Cretaceous System. Older Mesozoic and Palezoic beds underlie these formations and consist primarily of shales, limestones, sandstones, siltstones, and evaporiteswith a total thickness of several thousand feet.

10. The Sentinel Butte Formation, the uppermost bedrock unit in the basin, is present only under the Coteau Du Missouri and is lithologically similar to the underlying Tongue River Formation. The Tongue River Formation is present in the western two-thirds of the basin and in the Turtle Mountain and underlies glacial and alluvial sediments in the proposed project areas. This formation is described in detail in the discussion of foundation materials. Exposures of the Cannonball Formation occur in the Souris River valley from Verendrye upstream to Sawyer. This unit is a marine deposit which consists of thin, alternate beds of sandstone, siltstone, and sandy shale. The total thickness of the uneroded Cannonball Formation is not known, but the thickness of exposed beds in the vicinity of Sawyer is approximately 40 feet. The underlying, or older, rock formations are below the influence of the proposed work and are, therefore, not discussed.

11. The structural geology of the Souris River basin has not been determined in detail. Regionally, the subsurface structure consists of southwesterly dipping Palezoic beds truncated by Mesozoic beds that dip less

steeply to the southwest. The regional dip of all the beds is gentle and is obscured by local variations in some areas. Tertiary beds available for study at the surface exhibit local structural irregularities and lithologic variations that make deatiled correlation and structural analysis questionable.

12. The basin is structurally stable and without tectonic disturbances of regional or local magnitude. Current seismic risk references show the basin to lie in zone 1 or a non-critical area that could expect only minor damage from any probable earthquake.

GROUND WATER

13. Groundwater is an important natural resource in the Souris River basin where its occurrence and quality vary with location and depth. Considerable detailed information on the ground-water conditions in most areas of the basin is available. The scope of this study, however, does not warrant a presentation of more than a summary of ground-water conditions.

14. Ground water in the basin is obtained from glacial deposits, recent alluvium and bedrock aquifers. Wells in the glacial deposits are developed in sand and gravel lenses or beds, debris-filled valleys, glacial outwash channels on the till plains, and glaciofluvial deposits in the river valleys. In a few places these aquifers will yield more than 500 gallons per minute of good quality water, but such yields are rare. In many places the aquifers are too thin, are of small areal extent, or the rate of natural recharge is too slow to provide sustained yields of more than a few gallons per minute. Shallow or surficial deposits of sand and river-valley aquifers generally produce water of good quality, but water from the more deeply buried aquifers commonly contains objectionable concentrations of iron, sulfate and dissolved solids.

15. Development of wells in recent alluvium is restricted to the river valleys. Water-bearing strata in the alluvium are generally thin and are not considered important sources of water.

16. Bedrock aquifers in the basin consist of the Cretaceous Dakota Group, Fox Hills and Hell Creek Formations, and Tertiary Fort Union Group. Water from the Dakota Group is generally saline and is used mainly for pressurizing oil fields. Water from the Fox Hills and Hell Creek is a soft, sodium bicarbonate or sodium chloride type and is not recommended for human consumption. Gas is present with the water in the Fort Union Group and basal drift aquifers in eastern Renville and western Bottineau Counties. When sufficient gas is present, it lifts the water in a well to the ground surface and causes the well to flow. This gas-lift phenomenon was once common in the area but has decreased appreciably with development of the aquifer.

17. Sufficient ground water sources have been developed throughout the basin to maintain adequate municipal and domestic supplies; although, in some cases the quality of the water in domestic wells probably does not

meet standards recommended by the U.S. Public Health Service. The largest user of water in the basin is the city of Minot which obtains adequate water supplies from the Souris River along with buried-channel and glaciofluvial aquifers known as the Minot, North Hill, South Hill, Northest buried-channel, Lower Souris and Sundre Aquifers. The combined aquifer system has a large areal extent and storage capacity, but unmanaged withdrawals could easily exceed natural recharge. Therefore, the aquifers must be properly managed to insure a continued supply of water for the future.

SITE TOPOGRAPHY, SUBSURFACE CONDITIONS, AND FOUNDATIONS MATERIALS

18. The topography and subsurface conditions for each site are presented in this report by site topographic maps showing the proposed structures and generalized foundation profiles that show the interpreted subsurface conditions. Foundation materials for all of the proposed structures may be classified in the broad categories of River Alluvium, Glacial Sediments or Tongue River Formation. Except for minor variations in the alluvium, the general properties of each category are similar at all sites; therefore, a discussion of the materials by category is adequate for this study and is presented in the following paragraphs.

19. RIVER ALLUVIUM

The River Alluvium was deposited during aggredation of the Souris and Des Lacs River valleys following the recession of glaciers from the area. Material in the Souris Valley averages over 100 feet thick with a maximum known thickness of 160 feet. This material is predominantly medium to high plasticity clays with occasional interbeds of fine sand and silty fine sand. Some of the more plastic clays resemble lacustrine clays and may have been deposited in temporary valley lakes. River Alluvium in the Des Lacs valley has a maximum known thickness of 70 feet and consists of interbedded silty sand, clay and silt with occasional beds of clean sand.

20. GLACIAL SEDIMENTS

Except for a sand and gravel terrace deposit at Lake Darling Dam, the glacial sediments consist almost entirely of heterogeneous sandy clay till. Scattered gravel and occasional cobbles or boulders, thin beds, lenses, and channels of sand occur throughout the till. The sand and gravel terrace at Lake Darling Dam is located on the left abutment and exhibits a wide range of grain sizes, varies from silty to clean and has an abundance of cobbles and boulders.

21. TONGUE RIVER FORMATION

The Tongue River Formation is a terrestrial deposit laid down in lakes, swamps and broad floodplains of eastward flowing rivers during the Paleocene Epoch of the Tertiary Period. The formation is characterized by vertical and horizontal variations in lithology consisting essentially of mixtures of clay-, silt- and sand-sized particles. These constituent materials not only occur in numerous combinations but also exhibit sedi-

mentary structures ranging from finely laminated to massive. In addition, a change from one dominant particle size or sedimentary structure to another is often gradational or subtle so that classification into correlative units is difficult. The formation is often described as an "immature" rock that exhibits both the properties of a soil and the properties of a rock. Rock terms were used for this study based on apparent preference for these terms in the literature and previous usage with other Corps of Engineers investigations in the same formation. A classification system was developed for the Tongue River Formation which consists of five major lithologic types--shale, laminated siltstone, homogeneous siltstone, sandstone and carbonate concretions. The lithologic units are described on Plate B-12. The engineering properties and considerations are summarized as follows:

22. Permeability

The primary permeability of all units except the cleanest sandstones is so low the units are considered impervious. The primary permeability of the best sandstone encountered is estimated at less than 7×10^{-4} cm per second. Secondary permeability is expected to be a significant consideration in lignite beds. Fractured lignites account for drilling fluid losses and are sources of springs in outcrop areas. A low frequency of secondary interstices observed in the drill cores suggests that water problems will be restricted to lignites which may serve as seepage paths from reservoirs or sources of water if encountered in excavations.

23. Faulting

Several fault planes were identified as slickensided planes in the drill cores. More probably exist but were not identified due to difficulty of finding them without destroying the core samples. The depth of previous erosion in the valley and steep erosional surface on the buried Tongue River Formation indicate conditions favorable for the development of Proglacial slump blocks which parallel the trend of the valleys. Fault planes should, therefore, be expected in any excavation near river valley walls.

24. Jointing

A low frequency of jointing and fracturing was encountered in the borings and is considered a good representation of the subsurface condition. The presence of stress-relief joints that parallel the valley trend should, however, be expected in any excavation near a valley wall.

25. Excavation Properties

All material except cemented sandstone and limestone (carbonate concretions) can be excavated easily by ripping or can be tunneled by machine. Structural excavations, with the same exceptions, can be cut to close tolerance with a coal saw.

26. Bearing Capacity

The most critical unit as far as bearing capacity is concerned is

shale. It is recommended that unweathered shale be considered to have an allowable bearing capacity of 4 tons per square foot. The bearing capacity of weathered shale is considered to be equivalent to the overlying glacial till.

27. Rebound

The Tongue River beds exist in an over-consolidated state due to previous sediment and ice loads greatly in excess of the load exerted by the existing cover of sediments. For this reason, rebound of the Tongue River Formation in deep excavations has caused problems on other projects. Rebound must be considered a potential problem in any major excavation.

28. Slope Stability

Slope failures in the Tongue River are evident in the region but are generally due to steepening of a stable slope by erosion or excavation. Designed slopes in the Tongue River Formation at Garrison Dam have reportedly remained stable for 27 years. The most critical element anticipated to cause slope stability problems at the proposed facilities is exposure of the glacial till-Tongue River contact.

29. Foundation Protection

Protection of structural foundations is necessary to prevent deterioration of the foundation between the time of excavation and concrete placement. This is expected to be especially critical for laminated siltstone and shale. Initial underexcavation with excavation to final grade immediately before concrete placement is recommended for these units.

WATER TABLE

30. An accurate water table has not been determined at any of the proposed sites. An inferred water table is, therefore, shown on the foundation profiles and is based on limited water level data from borings and the base of the zone of oxidation. The water table is inferred from these data to be quite high and in most cases well above the base of excavation. Ground water is, however, not expected to be a major problem in any excavations due to the overall low permeability of the materials. Minor discharge from sand and gravel seams in the till and occasional sandstone beds in the Tongue River Formation is expected. Fractured lignite seams in the Tongue River should cause the greatest water problem in excavations but are not expected to be a significant concern. The delineation of the water table and water-bearing characteristics of the more pervious beds and lignite seams will be refined in the investigations for detailed design.

SOURCES OF STONE AND AGGREGATE CONSTRUCTION MATERIALS

31. Concrete aggregate of acceptable quality can be produced locally from gravel pits in glacial terrace deposits along the Souris and Des Lac Rivers. The material must, however, be carefully processed to remove iron-oxide concretions and shale.

32. Riprap and bedding are available locally. Riprap must be obtained from field stone piles of glacial boulders within a radius of 15 miles from the projects and from oversized material screened from gravel production. The supply of boulders in the area is being consumed and will eventually be depleted. At that time, riprap would have to be shipped in from outside the area. The closest reliable source of quarried stone is Ortonville, Minnesota, a distance of 400 miles. Bedding material can be produced from local gravel pits.

ECONOMIC GEOLOGY

33. Mineral resources in the Souris River basin that either have economic value, have had economic value or have economic potential include lignite, sand and gravel, glacial till, glacial boulders, brick clay, petroleum, natural gas, and salt. Those resources within the reasonable area of influence of the proposed facilities are sand and gravel, glacial till, glacial boulders and petroleum.

34. SAND AND GRAVEL

Sand and gravel deposits are abundant throughout the basin. Commercial operations are usually developed in river-terrace and diversion-channel deposits. Ice-marginal and outwash-channel deposits are next in importance. Kames, eskers, and overridden ice-contact deposits contain sufficient material for small, local projects. The southern part of the Lake Souris area contains huge quantities of sand that are essentially undeveloped. Material from nearly all deposits is adequate for road gravel, and material from most larger deposits can be processed for concrete aggregate. Except for the sand and gravel consumed in construction, the proposed projects would have no effect on future development of sand and gravel resources.

35. GLACIAL TILL

Sandy gravelly clay till is available in unlimited quantities. Its value as a resource would, therefore, not be affected by the proposed projects.

36. GLACIAL BOULDERS

Glacial boulders are scattered on the surface throughout the Coteau Du Missouri, ground-moraine plain, and river terraces. The boulders are the only source of riprap in the basin and must be collected from scattered piles cleared from farmers' fields or where they are naturally abundant on the surface of uncultivated areas. Stockpiles of oversized material screened from the numerous gravel operations in the basin are also important sources of boulders. Construction of the proposed projects would consume a significant amount of the boulders within a radius of several miles.

37. PETROLEUM

Producing oil wells have been developed near the Souris River valley

in the vicinity of Lake Darling. Further development of oil resources is possible near the proposed projects. Such development would, however, be compatible with the construction and operation of the facilities as proposed.

SUBSURFACE INFORMATION AND TESTING

38. Borings have been taken at the Lake Darling Dam site, as well as at the following sites:

Below Lake Darling Dam	Above Lake Darling Dam
1) Johnson's Addition	1) Eckerts Ranch
2) Brooks' Addition	2) Soo Line Railroad Crossing
3) Talbot's Nursery	3) Highway 5 Crossing
4) Country Club Acres and Robinwood Estates	4) McKinney Cemetery
5) King's Court and Rostad's Addition	5) Renville County Park
6) Tierrecito Vallejo	
7) Sawyer	

To date no borings have been taken at the State Highway 28, FAS 3809 (Old FAS 729) and FAS 3828 (Old FAS 471) road raises, or at the Fish and Wildlife Service's wildlife refuge dams. Subsurface information, testing and improvements for Velva, North Dakota, have been presented in Lake Darling Flood Control Project, Souris River, North Dakota, DM No. 4, Feature, Velva Improvements, dated November 1982, and are, therefore, not discussed in this appendix.

39. A total of 82 borings and test pits have been taken at the various structure sites. The locations of the borings are shown on the plans of the individual structures. Logs of the borings for each structure are presented in order of increasing boring numbers on plates following the plan for each structure or each combination of structures.

40. Laboratory tests performed to date include in situ moisture contents, liquid and plastic limits, mechanical analyses, undisturbed and remolded strengths, consolidation and compaction. In situ moisture contents and liquid and plastic limits are shown on the boring logs. Other individual laboratory test results are presented as follows: Lake Darling Dam, Plates B-44 through B-65; Soo Line Railroad, Plates B-66 through B-75; and State Highway 5, Plates B-76 through B-84.

41. The individual strength test results were used to develop summary strength plots. The plates showing the summary strength plots for the materials at a given structure are grouped with other plates that pertain to that particular structure.

LAKE DARLING DAM

42. GENERAL

Currently, the top of dam elevation is 1606.0, the upstream slope is approximately 1V on 2.7H, and the downstream slope is approximately 1V on 2.2H. The existing Lake Darling Dam has an ungated primary spillway on the left abutment and an ungated, grass-lined, emergency spillway on the right abutment.

43. The existing Lake Darling Dam will be extensively modified. The top of the dam will be raised 8 feet, from elevation 1606.0 to elevation 1614.0. A new gated spillway with low flow outlets located in the gate piers will be constructed on the left abutment replacing the old outlet works and two ungated spillways.

44. The plan of the Lake Darling Dam is shown on Plate B-1. Foundation conditions at the site are shown on the geologic profiles on Plates B-3 and B-4.

45. EMBANKMENT DESIGN

A typical embankment section is shown on Plate B-2. The embankment will have a top width of 40 feet, the same width as the existing embankment, and will be surfaced with a 24-foot wide paved roadway. The existing upstream slope, which averages 1V on 2.7H, will be flattened to 1V on 3.75H to meet sudden drawdown criteria. Rockfill will be used to flatten the underwater portion of the slope. To minimize the rockfill section the centerline of the raised embankment has been moved downstream of the existing embankment centerline. Above elevation 1600 much of the existing riprap is undersized, and coverage of the slope is inadequate. Existing riprap in this zone will be removed and placed in the rockfill section. In general, the embankment contact areas will be stripped to either a 6-inch or 12-inch depth as considered appropriate. The upstream half of the crest of the existing dam will be stripped to a depth of 2 feet to assure good contact with the impervious fill in the upstream portion of the existing embankment. A sand drain will be incorporated in the modified embankment, as shown on Plate B-2. The downstream slope of the existing embankment, which averages 1V on 2.2H, will be flattened to 1V on 3.75H. A berm will be placed on the downstream slope beginning at elevation 1603.3, extending downstream at a 1V on 50H slope, for 180 feet. The large berm provides a disposal area for excess excavation from the new spillway on the left abutment, and is not required for stability.

46. SEEPAGE CONTROL

Old drawings indicate that the existing embankment was designed as a zoned embankment. The upstream 40± percent of the embankment consisted of relatively impervious fill and the downstream 60± percent of the embankment consisted of pervious bank-run rock, gravel and sand. Stripping of the original ground surface to an unknown depth to be determined by the engineer was required upstream of the embankment centerline. No stripping was required downstream of the embankment centerline. About 45 feet up-

stream of the centerline a muck trench (cut-off trench) was excavated into the foundation soils. The bottom width of the trench was 6 feet but the depth was to be determined by the engineer. In the river channel section the trench was about 75 feet upstream of the centerline and a wood sheet-pile cutoff was driven on the trench centerline. Subsequent to the original construction, pervious fill was placed on the upstream slope to increase the top width of the dam from 31 feet to 40 feet and to provide a uniform upstream slope on which to place new riprap. Borings taken at the downstream shoulder of the dam encountered both pervious and impervious fill, indicating that the actual embankment zoning was not as pure as shown on the drawings. On the basis of existing drawings alone, it is difficult to judge the adequacy of the seepage cutoff in the existing embankment and foundation soils. A somewhat higher quantity of seepage than would normally be expected from a well designed earth dam has been noted during field inspections of the embankment both during and following recent floods, especially in the reach between the outlet works and the right abutment. However, there has been no evidence of seepage exiting on the downstream slope of the embankment nor has there been any evidence of material transport or other seepage-related instability. Borings along the embankment alignment indicate that the near surface foundation soils in the valley consist of SM or finer materials. One relatively thin SP layer, considered to be discontinuous, was encountered in boring 76-98M at a depth of about 10 feet beneath the existing embankment. No highly pervious zones that would have a direct connection to the pool are evident. The proposed modification of the embankment will not significantly affect the existing quantity of seepage, but better control of the seepage will be provided by the internal sand drain and toe drain. In addition the seepage path through the foundation soils to the toe of the modified embankment will be increased more than 2-1/2 times. Planned seepage control for the modified embankment will, therefore, consist of assuring good contact between the upstream relatively impervious zone of the existing embankment and new impervious fill placed to raise the embankment. In addition, the internal sand drain shown on Plate B-2 will be constructed to control seepage through the embankment and/or foundation soils. A perforated pipe toe drain will be installed near the downstream end of the horizontal sand drain to permit collection and monitoring of seepage. The pipe toe drain will discharge either into the spillway discharge channel or into the old river channel downstream of the modified embankment. A short section of cut-off trench will be required on the left abutment to cut off the sand and gravel terrace deposit on the left abutment shown on Plate B-3.

47. STABILITY

Available soil strength data have been summarized on Plates B-8 through B-11. The preliminary design strength parameters and, where necessary, assumed design strength parameters were used to perform stability analyses of the modified valley embankment section. The strength parameters used are shown on Plate B-5.

48. The stability analyses were performed using the Corps' Computer Library Program 10013 (old St. Paul District 741-X6-F5030) entitled, "Slip Circle Slope Stability with Side Forces." Results of the stability

analyses have been summarized on Plates B-5 through B-7. Any further stability analysis will be completed at a later date for inclusion in the Lake Darling Dam Embankment Feature DM.

49. SETTLEMENT OF EMBANKMENT FOUNDATION SOILS

The maximum depth of the river alluvium is about 140 feet at the Lake Darling Dam site, and some of the river alluvium is made up of highly compressible (CH) clays. Preliminary settlement calculations were completed for GDM No. 2, "Flood Control Burlington Dam," at two locations beneath the modified embankment proposed in that report. The computations indicated that for the modified embankment, 20 inches of settlement could occur at the downstream toe of the existing embankment. This indicates that for the currently proposed modified embankment settlements on the order of 20 inches will occur. Required overbuild will, therefore, be in the range of 12 to 18 inches. Revised settlement calculations will be presented in the Lake Darling Dam Embankment Feature DM. The settlement will be sufficiently large to preclude the placement of concrete structures in the valley. The new concrete gated control structure will, therefore, be placed in the left abutment so that it can be founded on the overconsolidated Tongue River formation. The existing outlet works, which is located in the valley, will be removed once the new control structure is operational. Since the existing outlet supplies water to Ponds A, B, and C just downstream of the dam, a new water supply structure will be required. The new structure will be a gated, 42-inch diameter, reinforced concrete pipe which will be located in the right abutment to avoid settlement-related problems.

50. CONTROL STRUCTURE

The topography and the foundation conditions at the site favor placing the new control structure in the left abutment. The geologic profile at the centerline of the structure is shown on Plate B-4. The structure will be founded on the overconsolidated Tongue River Formation. Pervious layers near the base of concrete structure will be drained with pipes and/or sand drains to prevent uplift pressures from developing beneath the structure. Lignite seams near the base of concrete structure may require excavation or grouting for structural reasons. Rebound of the overconsolidated Tongue River Formation in the structure excavation is not expected to be a significant problem because of the relatively shallow depth of the excavation. However, the potential for rebound will be investigated further for the Feature DM.

51. PROPOSED DISTRIBUTION OF REQUIRED EXCAVATION

The total required excavation for the control structure and associated approach and discharge channels will be about 746,830 cubic yards. The required excavation will consist primarily of glacial till and Tongue River materials; however, some river alluvium will be excavated at the ends of the approach and discharge channels. Most of the glacial till and Tongue River materials from the excavations will be suitable for embankment construction. Some of the glacial till and Tongue River material and probably all of the river alluvium will be too wet to use in the

embankment and will have to be wasted. The amount of wet material is estimated to be about 20 percent of the total required excavation, or about 149,370 cubic yards. The remaining 597,460 cubic yards of required excavation is considered usable for embankment construction and backfill for the new structures. Required fill quantities include 25,460 cubic yards of backfill, 134,270 cubic yards of random fill and 227,900 cubic yards of impervious fill. Total required fill is, therefore, 387,630 cubic yards. The remaining 359,200 cubic yards of required excavation will be used to construct a berm on the downstream side of the embankment as shown on Plate B-2. The proposed distribution of materials is preliminary and may be changed following completion of the next phase of the boring and testing program at this site.

52. CONSTRUCTION SEQUENCE AND DIVERSION PLAN

The following preliminary construction sequence has been developed for modification of Lake Darling Dam. The existing secondary spillway on the right abutment will be enlarged, with concrete and sheetpile crest protection installed, so that flow can be diverted through the secondary spillway and the existing low flow outlet while the new control structure is being built on the left abutment. Following modification of the secondary spillway, the primary spillway will be cofferdamed off to permit construction of the new control structure and as much of the new discharge channel as practical. Excavation for the new spillway and discharge channel will be used to complete the required embankment modifications to the maximum extent practical. When the new control structure is completed, the downstream cofferdam will then be removed and the discharge channel completed. The upstream cofferdam will then be removed and the approach channel completed. The new control structure will then be operational and diversion will no longer be required. A cellular sheetpile cofferdam can then be installed around the upstream end of the existing low flow structure, the structure excavated, removed, and the excavation backfilled. Removal of the cellular cofferdam and completion of the embankment and right abutment approach roads can then be accomplished.

SOO LINE RAILROAD RAISE

53. GENERAL

The existing Soo Line railroad embankment across Lake Darling will be raised about 3 feet. The subgrade elevation of the raised embankment will be 1607.0 so that with the placement of ballast and trackage the top of rail will be 1608.0. The centerline of the raised embankment has been located downstream of the existing embankment centerline to permit the existing track to remain in service during construction. The existing bridge, located in the river valley, will be replaced with a new bridge which, because of foundation conditions, has been located in the right abutment. The new bridge will be constructed on the downstream side of the track so that service can be maintained on the present track during construction. The plan, profiles, and sections of the proposed modifications are shown on Plate B-20.

54. EMBANKMENT DESIGN

The raised embankment will be constructed adjacent to the downstream slope of the existing embankment. The riprap on the downstream slope of the existing embankment will be salvaged to the extent practical and used on the raised embankment. Because the embankment crosses Lake Darling, which has a conservation pool elevation of approximately 1596, underwater placement of the lower portion of the fill will be required. Pervious fill will, therefore, be used to construct that portion of the embankment below elevation 1597. Above elevation 1597 the embankment will be constructed of random fill. The upstream slope of the raised embankment will be 1V on 3H above the top of existing embankment and will be protected with 15 inches of riprap placed on 9 inches of bedding. The downstream slope of the raised embankment will be 1V on 3-1/2H and will be protected with 18 inches of riprap placed on 15 inches of bedding.

55. STABILITY

Existing borings at the site indicate that the river alluvium has a maximum depth of about 55 feet and that the majority of the river alluvium consists of high plasticity (CH) clays. Available strength data for the river alluvium has been summarized on Plate B-21. End of construction and sudden drawdown stability analyses were performed for an embankment constructed to elevation 1610.0 (for the Phase II GDM No. 2, entitled, "Flood Control Burlington Dam"). The currently proposed embankment is 3 feet lower and thus will also meet criteria for those two stability cases. A complete stability analysis will be furnished in the Feature DM on the Soo Line Railroad Embankment.

56. SETTLEMENT OF EMBANKMENT FOUNDATION SOILS

The majority of the river alluvium is high plasticity (CH) clays. These clays are highly compressible, but the loading and other factors are such that settlement of the embankment will be relatively small. Since the existing embankment occupies about 45 percent of the volume of the total embankment, and since 5 to 7 feet of the pervious fill will be placed underwater, effective stress increase in the foundation soils will be significantly less than if the complete embankment was constructed at one time and underwater placement was not involved. Under present conditions the river alluvium is also preconsolidated to some extent because of the reduction in effective stress caused by the submergence of the upper zone of the river alluvium by the Lake Darling pool. This preconsolidation also helps to reduce the settlement. Calculations indicate that construction of the raised embankment will cause about 5 inches of settlement at the centerline of the existing embankment and about 12 inches of settlement at the centerline of the raised embankment. The settlement is considered sufficient to justify locating the new bridge in the right abutment where the fill height will be less and the bridge can be founded on the much stronger glacial till.

57. PROPOSED DISTRIBUTION OF REQUIRED EXCAVATION AND BORROW

The 109,510 cubic yards of pervious fill required to construct the portion of the main embankment below elevation 1597.0 can be obtained from a sand and gravel terrace deposit on the right bank just upstream of the embankment. The 288,700 cubic yards of required excavation contains sufficient glacial till to provide the 105,810 cubic yards of random fill required to complete the main embankment. Present plans are to waste the 182,890 cubic yards of excess excavation along the right abutment. However, consideration will be given to the possibility of using some of the excess excavation as random fill for the State Highway 28 road raise which is about 1 mile upstream of the Soo Line crossing.

ROAD RAISES - STATE HIGHWAY 28 AND FAS ROUTES 3809 AND 3828

58. These road relocations have been grouped together for discussion purposes since the raises will be relatively small and embankment designs will be similar. FAS 3809 (old FAS 729) and State Highway 28 are north-south roads that cross the Souris River valley 3 miles north of State Highway 5 and 1 mile north of the Soo Line crossing, respectively. FAS 3828 (old FAS 471) is an east-west road that crosses the Souris River valley 2-1/2 miles south of the Soo Line crossing. State Highway 28 and FAS 3828 will be raised to elevation 1607.0 to decrease the frequency of inundation. The maximum embankment raise will be about 2 feet for State Highway 28 and about 5 feet for FAS 3828. The centerlines of the raised embankments will coincide with the centerlines of the existing embankments to the maximum extent practical in order to minimize settlements and fill quantities. Although subsurface data at these sites is lacking, it is believed that 1V on 3H slopes will provide stable embankments and that settlements caused by the relatively small raises will not be excessive. The slopes of the embankments will be riprapped to provide protection from wave action. Fill for the embankments will be obtained from borrow areas since there will be no significant amount of required excavation at the road raises. Random fill can be obtained from glacial till deposits at either end of the road raises. Pervious fill will be required for those portions of the State Highway 28 and FAS 3828 embankments below elevation 1597 since the two roads cross Lake Darling. The pervious fill can be obtained from sand and gravel terrace deposits at the right abutment of both raises. A new bridge will be constructed to replace the existing bridge on State Highway 28. On FAS route 3828 the superstructure of the existing bridge will be raised to elevation 1608.5. Prior to the preparation of the Feature DM on these road raises, boring and testing will be required to obtain the soil parameters needed for final design of the embankments and the new bridge on State Highway 28. The plan view for State Highway 28 and FAS route 3828 are shown on Plates B-23 and B-24, respectively. These two roads will not be scheduled for simultaneous construction because of their proximity to each other and the need to provide alternate routes for construction detours. Improvements of FAS route 3809 will consist of placing 4 inches of new stabilized aggregate surfacing and placing riprap and bedding on the existing embankment slopes to provide wave protection when Lake Darling is high. Additional design and analyses will be included in the Feature DMs on the road relocations.

STATE HIGHWAY NO. 5 ROAD RAISE

59. State Highway 5 is the major east-west highway crossing over the Souris River in the reach between the Canadian border and Lake Darling Dam. Present plans call for raising the crossing from about elevation 1605.0 to a minimum elevation of 1607.5. Two spans will be added to the existing bridge and the bridge deck will be raised to provide a roadway surface elevation of 1610.5. It is assumed that an older Highway 5 bridge, which is still in place just upstream of the present bridge, can be used to detour traffic around the present bridge while required modifications are made. The remaining embankment will be raised by raising 1/2 of the embankment at a time, thus keeping one lane open for traffic. The plan, profile, and sections for the raise are shown on Plate B-25. The embankment will be constructed of random fill and will have a top width of 40 feet with 1V on 3H side slopes. Prior to fill placement the existing ground will be stripped 6 inches. Upstream and downstream slope protection will consist of 18 inches of riprap placed on 9 inches of bedding. The existing pavement will be removed and replaced by a bituminous paved surface 32 feet wide. Existing borings at the site indicate that the river alluvium has a maximum depth of 60 feet and consists primarily of low to high plasticity clays. Available strength data for the river alluvium has been summarized on Plate B-27. The random fill for the embankment will consist of glacial till obtained from a borrow area on the right abutment. Remolded strength parameters are summarized on Plate B-26. A partial stability analysis was run on this embankment in Phase II GDM No. 2, entitled, "Flood Control Burlington Dam," which indicated satisfactory factors of safety for the embankment at a top elevation 1626.0. Since plans currently call for an embankment with a top elevation that varies from 1607.5 to 1610.5, no stability problems are anticipated. The reference cited previously indicated that 20 inches of settlement would occur if the embankment were raised to elevation 1626.0 (a 21-foot raise). Current plans call for a raise of only 2.5 to 5.0 feet, and thus much smaller settlements are anticipated. Detailed analyses of the embankment will be furnished in the Feature DM on Highway 5.

60. A total of 38,960 cubic yards of random fill is required to construct the embankment and detour. Only about 10,920 cubic yards of this total will be obtained from required excavation. The remaining 28,040 cubic yards of random fill will be obtained from a borrow area on the right abutment. About 88,680 cubic yards of channel excavation will be required for the new bridge; however, the channel excavation will be primarily river alluvium that is too wet for use as random fill. Channel excavation that is unsuitable for embankment fill will be disposed along the right valley wall upstream and/or downstream of the embankment.

ECKERT RANCH AND MCKINNEY CEMETERY LEVEES

61. These two sites have been grouped together for discussion purposes since the levee designs at each site will be similar. Plate B-29 shows the proposed plan for Eckert Ranch, and Plate B-31 shows the plan,

boring log, and section for McKinney Cemetery. Borings for Eckert Ranch are shown on Plate B-30. The Eckert Ranch site is on the left side of the valley about 2 miles north of the Lake Darling Dam, while the McKinney Cemetery is located 1/2 mile south of State Highway No. 5. Each site will be protected from the increase in the Lake Darling pool by a levee. The levees will have a top elevation of about 1610.0, with 1V on 3H side slopes. Although some subsurface data has been obtained for each site, no testing is available. Consequently, no stability or settlement analyses have been completed. However, it is believed that 1V on 3H slopes will provide stable embankments and that only minor settlements will occur. The riverward slopes of the levees will be riprapped to provide protection from wave action. Required borrow will be obtained from the glacial till deposits on the valley walls. Further testing, design and analysis will be presented in the Feature DM for each site.

RENVILLE COUNTY PARK

62. Renville County Park is located about 2-1/2 miles north of State Highway No. 5. Present plans are to protect the area with a levee and a cut-off channel. The plan for Renville County Park is shown on Plate B-32. The levee will be constructed to elevation 1610.0, with 1V on 3H side slopes. The riverward levee slope will be riprapped to provide protection from wave action. Slopes of the cut-off channel will be 1V on 3H, and a control structure will be located at the upstream end of the cut-off. Five borings, shown on Plate B-33, have been taken along the proposed alignments. They indicate that much of the material excavated from the cut-off channel can be used to construct the levee. Excavated material that is unsuitable for levee construction will be disposed along the cut-off channel. Required borrow will be obtained from glacial till deposits on the left valley wall. No stability or settlement analyses have been completed to date, but experience indicates that the 1V on 3H slopes will be stable, and settlements will be relatively minor. Further testing, design and analysis will be presented in the Feature DM.

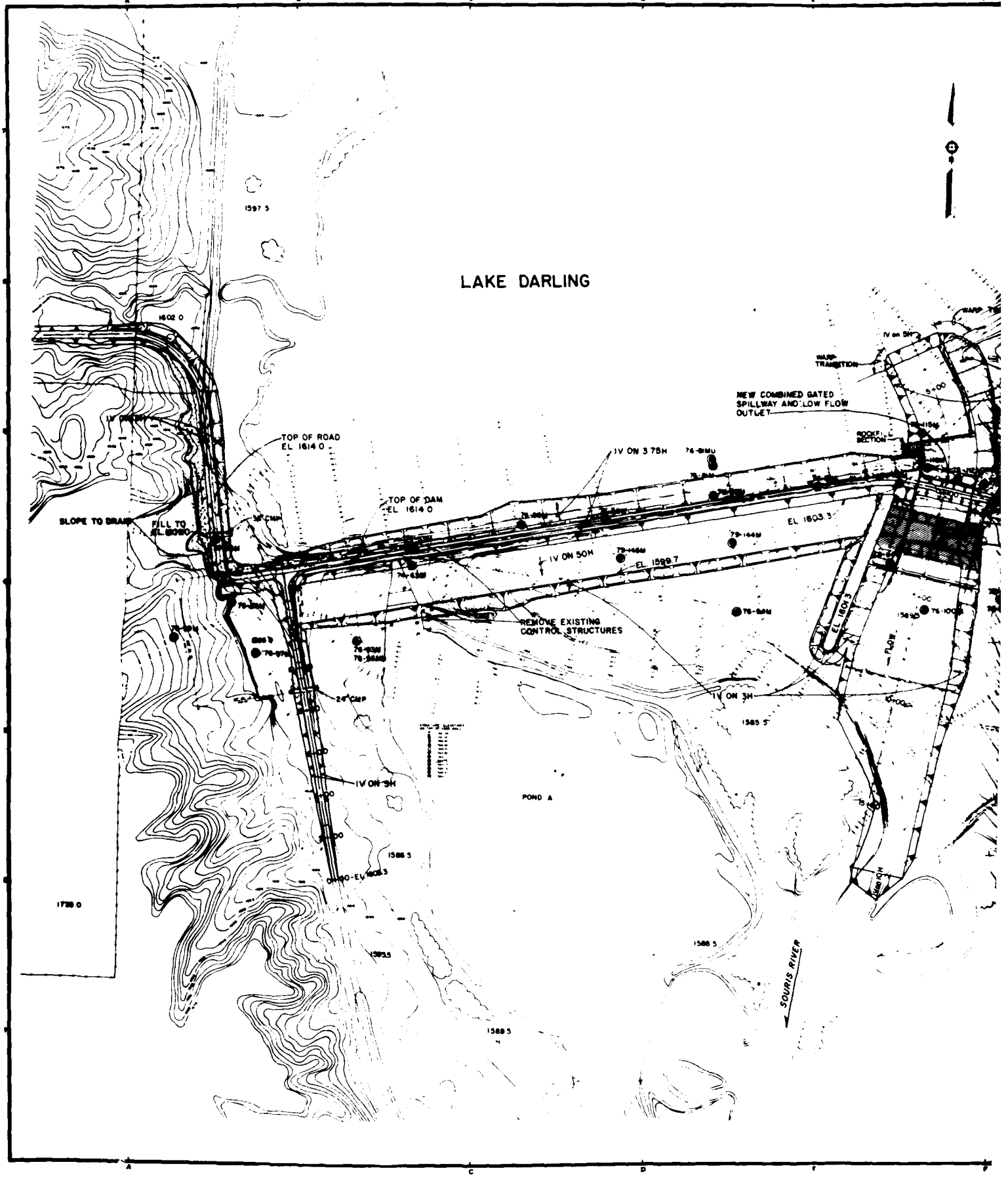
BURLINGTON TO MINOT LEVEES

63. Several residential areas below Lake Darling will require protection from the discharges of the reservoir under the present operation plan. These sites are as follows:

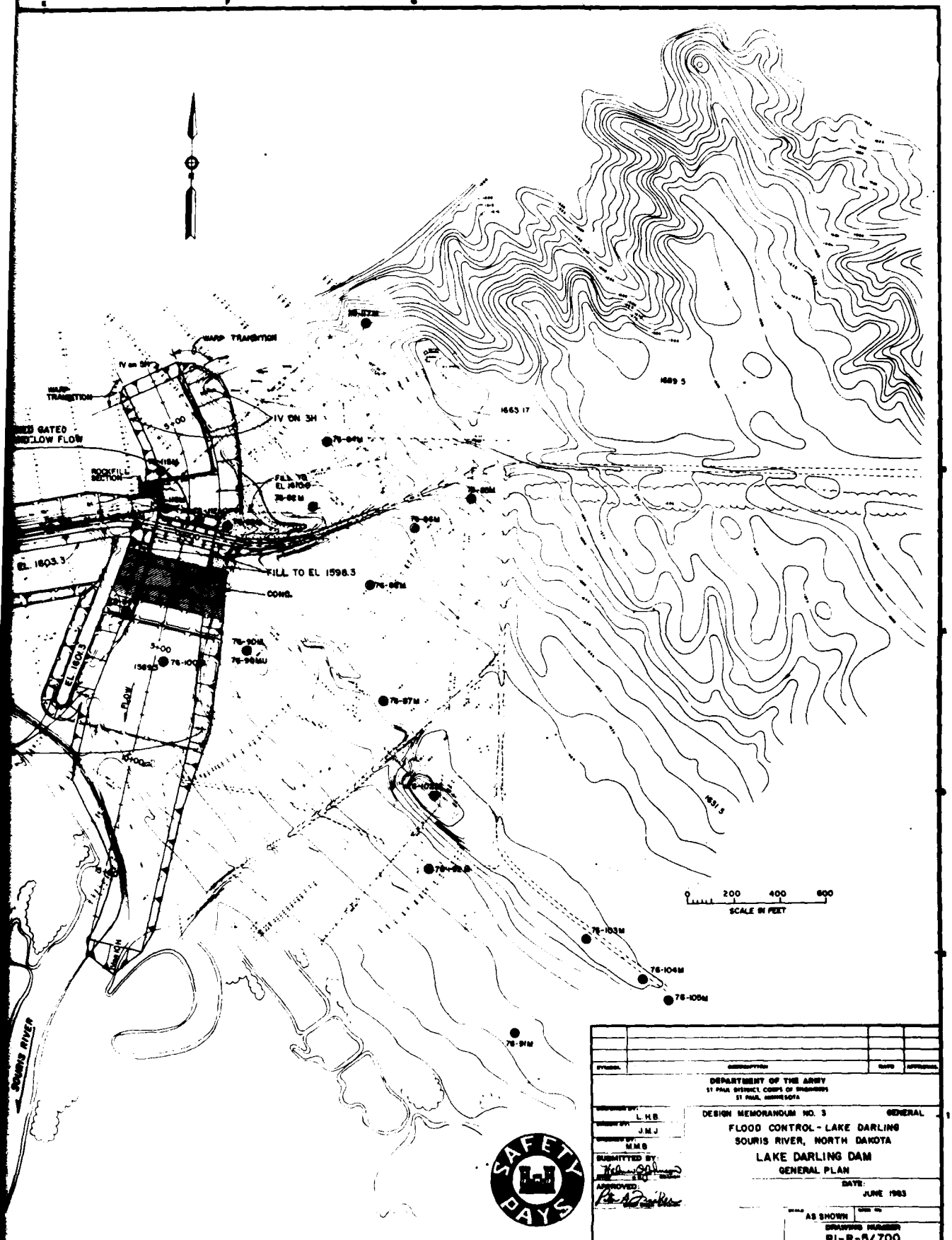
a. Johnson's Addition
b. Brooks' Addition
c. Talbot's Nursery
d. Country Club Acres
e. Robinwood Estates
f. Kings Court
g. Rostad's Addition
h. Tierrecito Vallejo
i. Sawyer

Plans for sites 1 through 8 are shown on Plates B-34 through B-40. The plan for site 9 is shown on Plate B-42. Each site will be protected with a levee with 1V on 3H side slopes. Some borings have been taken at each site and are shown on Plates B-41 and B-43. There is no test data available, therefore, no stability analyses or settlement computations have been performed. However, past experience in the area indicates that the embankments will be stable and settlements will be relatively minor. Required borrow for construction of the levees can be obtained from the glacial till deposits on either valley wall. Further boring, testing, design and analysis will be completed for each site in the appropriate Feature DM.

CORPS OF ENGINEERS



U. S. ARMY



DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
ST PAUL, MINNESOTA

DESIGN MEMORANDUM NO. 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

LAKE DARLING DAM
GENERAL PLAN

DESIGNED BY: L. H.B.
DRAWN BY: J.M.J.
TRACED BY: M.M.B.
SUBMITTED BY:
APPROVED:
DATE: JUNE 1983
SCALE: AS SHOWN
DRAWING NUMBER: RI-R-8/700
SHEET OF

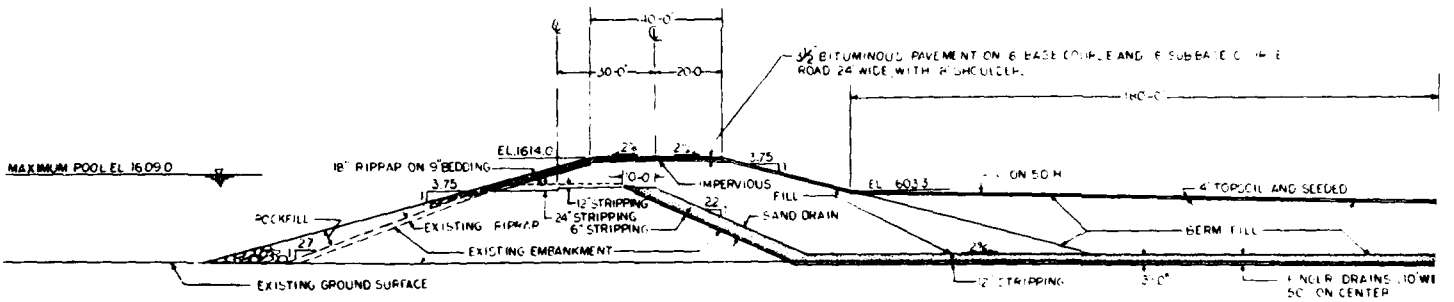
SAFETY PAYS

PLATE 8-1

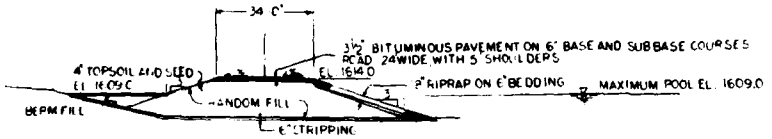
1

2

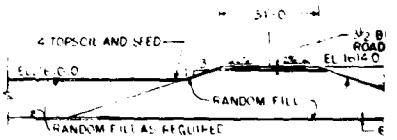
TYPICAL DISCHARGE CHANNEL SECTION
SCALE AS SHOWN BELOW
(SECTION TAKEN LOOKING U/S)



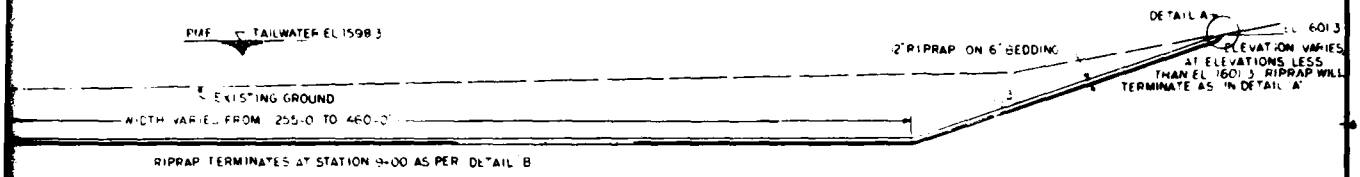
TYPICAL EMBANKMENT SECTION
SCALE 0 10 20 30 40 50 FEET



U/S TYPICAL SECTION - RIGHT ABUTMENT APPROACH ROAD
SCALE AS SHOWN ABOVE

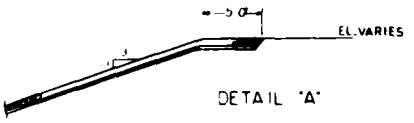


TYPICAL SECTION - LEFT ABUTMENT AP
SCALE AS SHOWN ABOVE

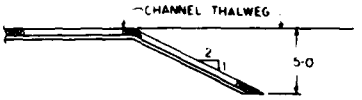


YPICAL DISCHARGE CHANNEL SECTION

SCALE AS SHOWN BELOW
(SECTION TAKEN LOOKING U/S)

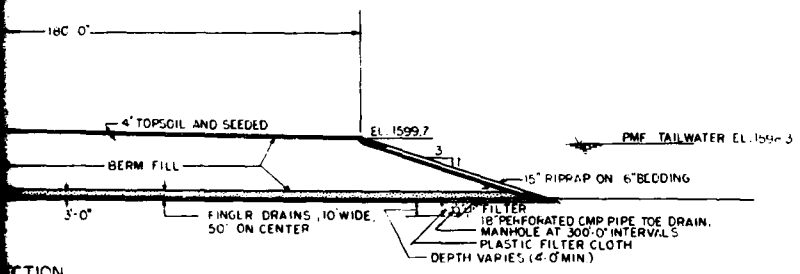


DETAIL "A"



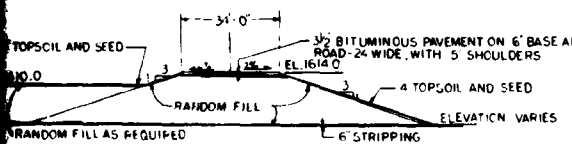
DETAIL "B"

SE AND 6" SUBBASE COURSE



CTION

FEET



YPICAL SECTION – LEFT ABUTMENT APPROACH ROAD

SCALE AS SHOWN ABOVE

SAFETY PAYS

SYMBOL	DESCRIPTION	DATE	APPROVAL

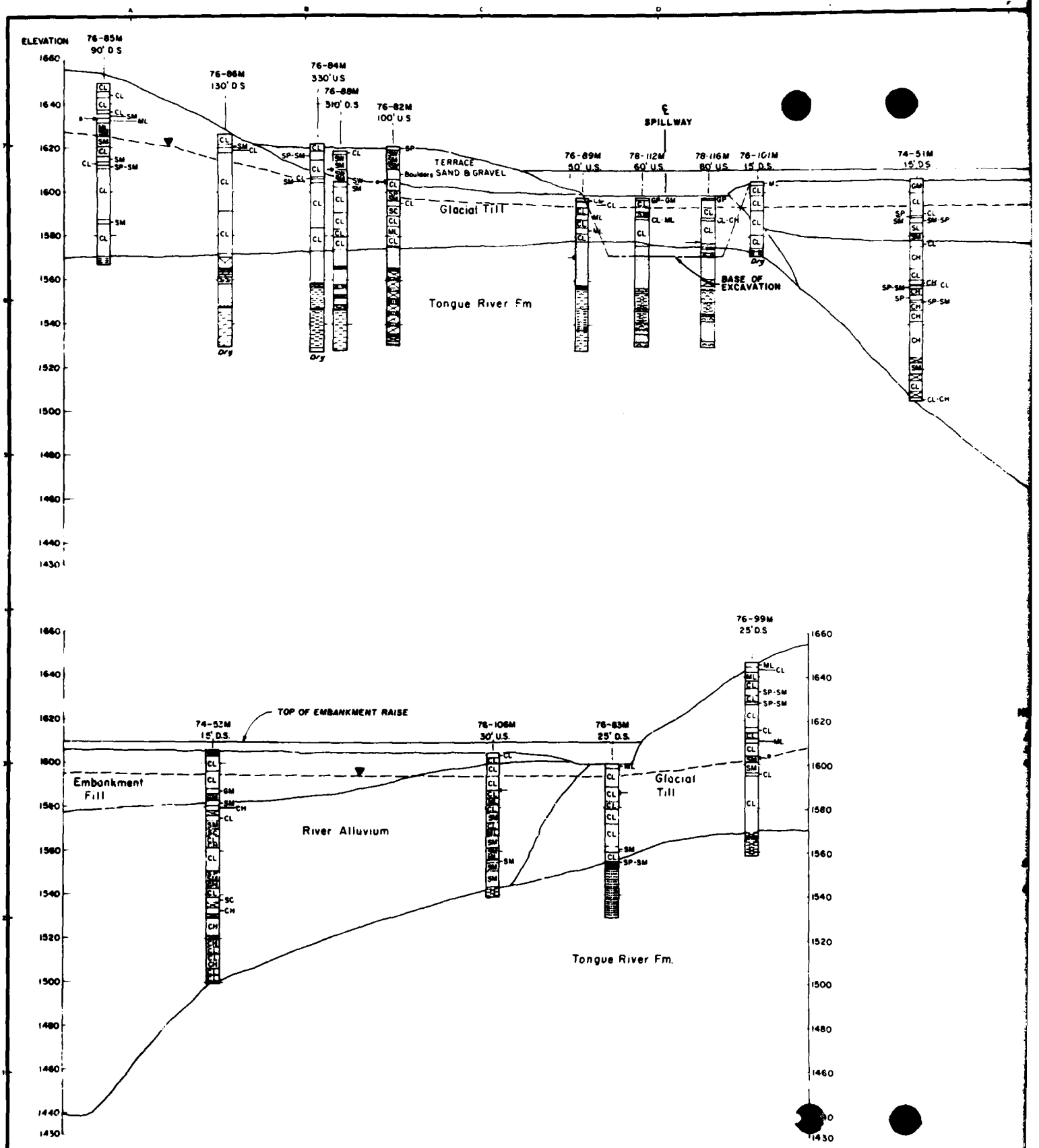
DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
ST PAUL, MINNESOTA

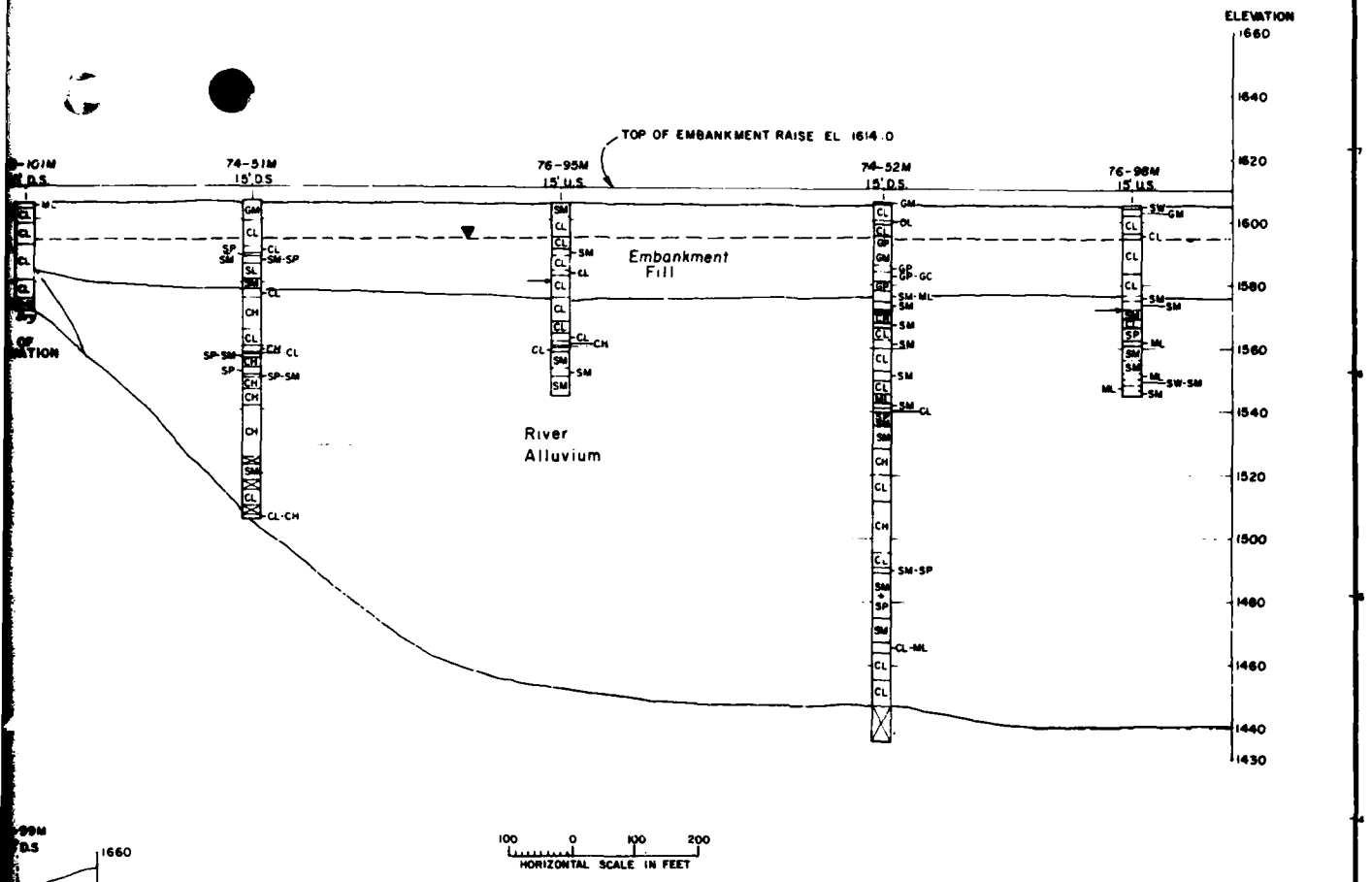
DESIGNED BY: LHB	DESIGN MEMORANDUM NO. 3 GENERAL
DRAWN BY: LHB	FLOOD CONTROL – LAKE DARLING
TRACED BY: M.M.B.	SOURIS RIVER, NORTH DAKOTA
SUBMITTED BY:	TYPICAL SECTIONS – LAKE DARLING DAM AND SPILLWAY
CHIEF, ENGINEERING DIVISION	APPROVED: DATE: JUNE 1963
SCALE: AS SHOWN	DRAWING NUMBER: RI-R-5/701
SHEET OF	

PLATE 3-2

1

2


ELEVATION
76-85M
90' D.S.
76-86M
130' D.S.
76-84M
330' U.S.
76-88M
310' D.S.
76-82M
100' U.S.
℄
SPILLWAY
76-89M
50' U.S.
76-112M
60' U.S.
76-116M
80' U.S.
76-101M
15' D.S.
74-51M
15' D.S.
TERRACE
SAND & GRAVEL
Boulders
Glacial Till
Tongue River Fm
BASE OF
EXCAVATION
Dry
1660
1640
1620
1600
1580
1560
1540
1520
1500
1480
1460
1440
1430
76-99M
25' D.S.
TOP OF EMBANKMENT RAISE
74-52M
15' D.S.
76-106M
30' U.S.
76-83M
25' D.S.
Embankment
Fill
River Alluvium
Glacial
Till
Tongue River Fm.



NOTES:

1. *Profile is viewed looking downstream.*
2. *Boring locations are shown on Plate B-1.*
3. *See Plate B-12 for Boring legend.*
4. *The water table is shown on the profile by the symbol _ _ _ ▽ _ _, the water table is inferred based on limited water-level data from borings and the base of the zone of oxidation.*
   Water levels in the borings marked with an asterisk indicate pervious water-bearing seams in the impervious till.
   Borings with no water level indicated and not shown as dry are those in which no water levels were determined.
5. *Distance of borings upstream and downstream from the profile line are indicated by U.S. and D.S.*
6. *Foundation or excavation limits shown by this symbol ——————.*

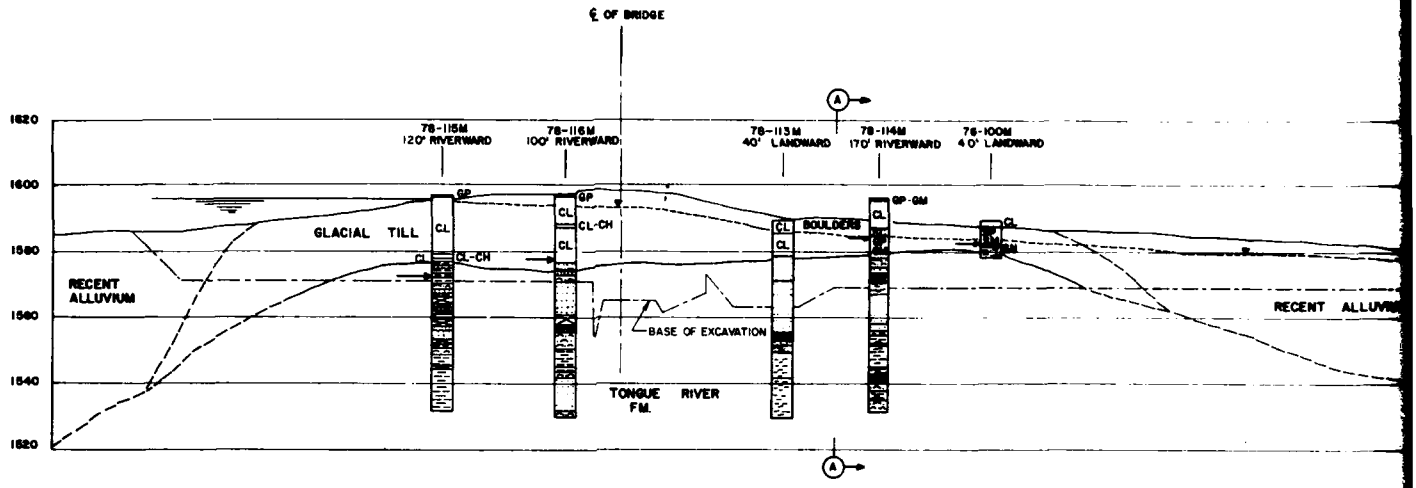
SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
ST PAUL, MINNESOTA

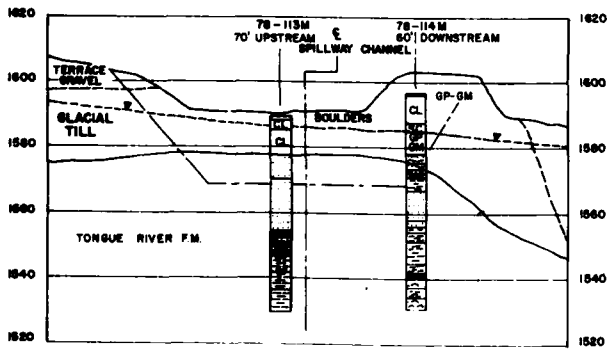
DESIGNED BY R.L.W. | DESIGN MEMORANDUM NO 3 GENERAL
DRAWN BY J.H.L.
CHECKED BY R.L.W.
SUBMITTED BY
APPROVED

FLOOD CONTROL
LAKE DARLING, NORTH DAKOTA
LAKE DARLING DAM
SUBSURFACE PROFILE
EMBANKMENT CENTERLINE

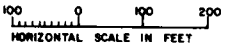
DATE JUNE 83
SCALE AS SHOWN
DRAWING NUMBER
RI-R-5/702
SHEET OF
PLATE NO. B-5

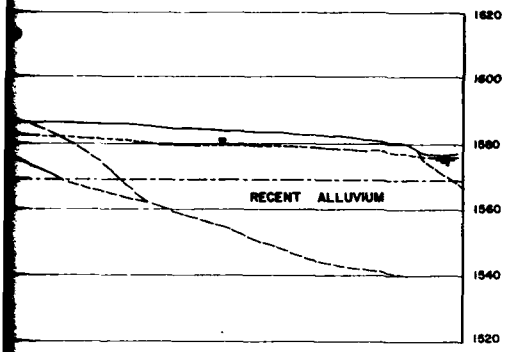


CENTER LINE OF SPILLWAY



SECTION A-A





NOTES:

1. *Foundation and excavation limits shown by dashed lines.*
2. *Water table explained on plate B-3*

100 0 100 200
HORIZONTAL SCALE IN FEET

SAFETY PAYS

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
ST PAUL, MINNESOTA

DESIGN MEMORANDUM NO. 3 GENERAL

DESIGNED BY: R.L.W.
DRAWN BY: J.M.J.
TRACED BY:
CHECKED BY: R.L.W.
SUBMITTED BY:
APPROVED:

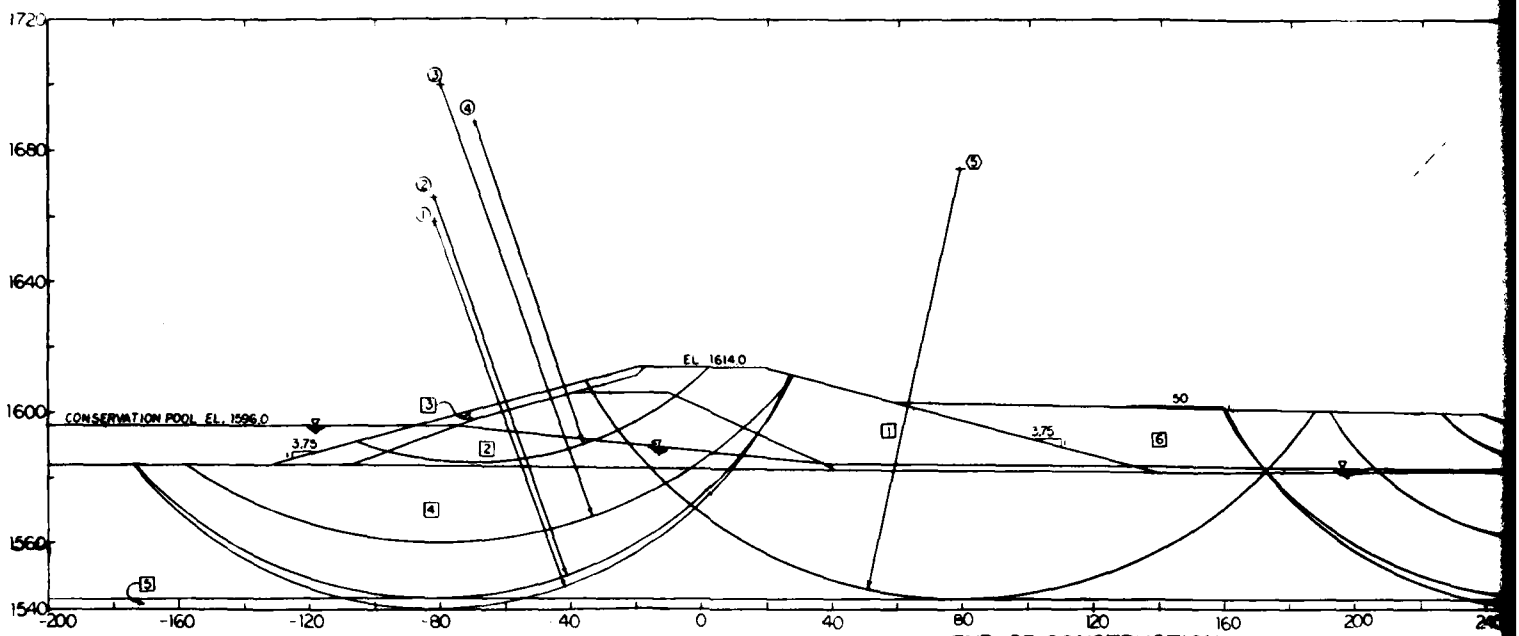
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
LAKE DARLING
SUBSURFACE PROFILE
SPILLWAY CENTERLINE

DATE: JUNE 1963

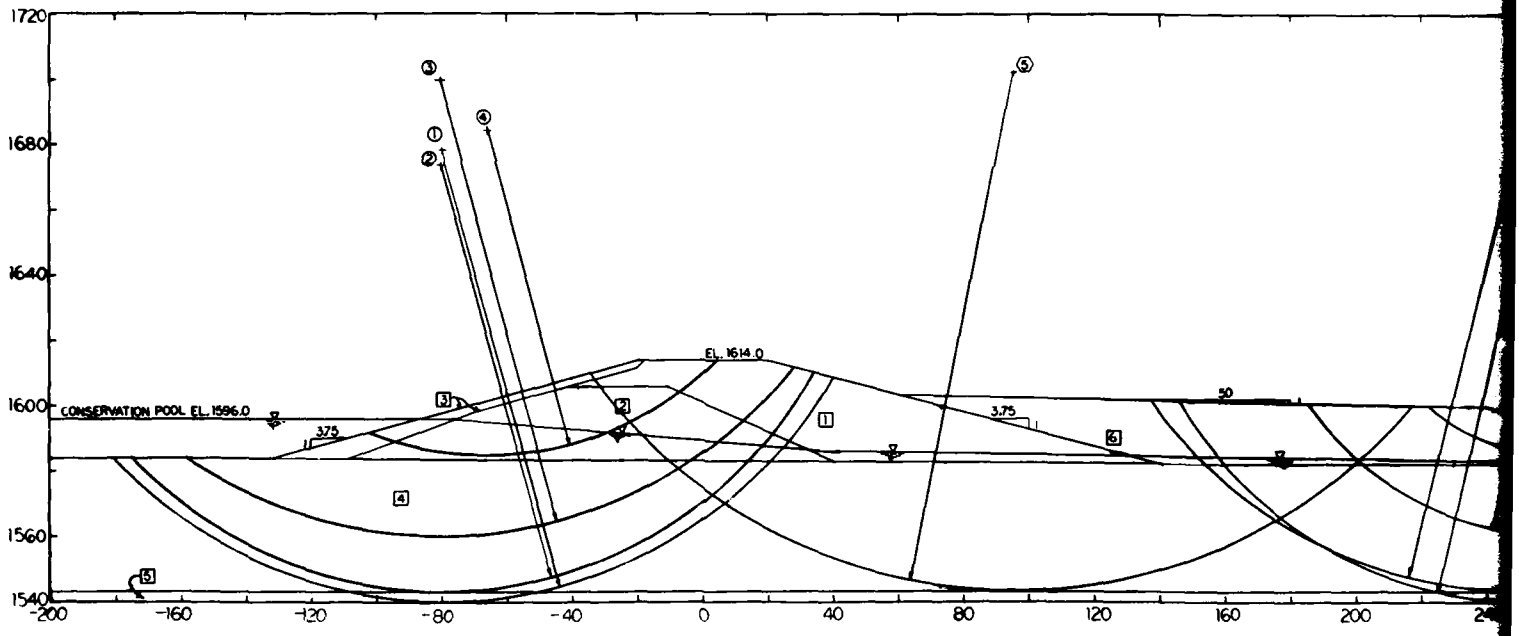
SCALE: AS SHOWN
DRAWING NUMBER: RI-R-5703
SHEET OF

PLATE NO. B-4

2



END OF CONSTRUCTION

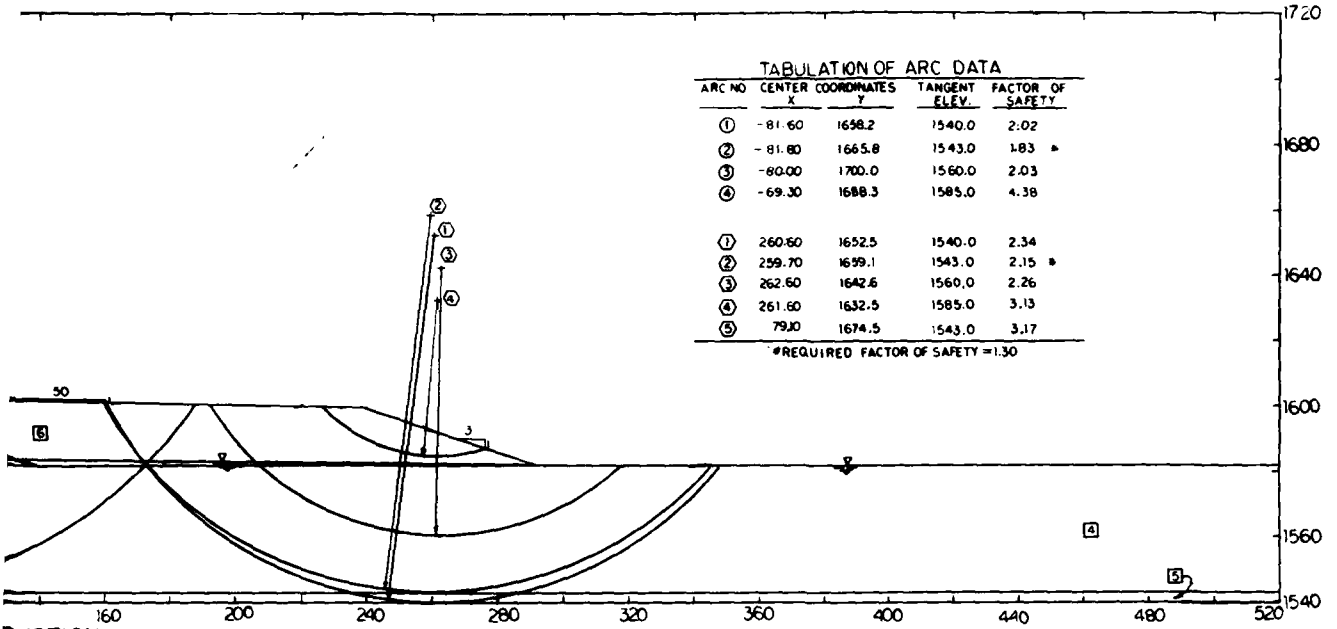


END OF CONSTRUCTION W/ EARTHQUAKE

SOIL PARAMETERS

SOIL DESCRIPTION NO.		UNIT WEIGHTS MOIST	UNIT WEIGHTS SATURATED	Q TEST C (PSF)	Q TEST φ (DEG)	R TEST C (PSF)	R TEST φ (DEG)	S TEST C (PSF)	S TEST φ (DEG)	(R+S)/2 C (PSF)	(R+S)/2 φ (DEG)
1	NEW EMBK. FILL	126.0	133.0	1730.0	2.0	200.0	12.0	0.0	29.5	100.0	20.75
2	EXISTING EMBK.FILL	118.0	123.0	1300.0[1]	4.3[1]	640.0	11.7	0.0	29.5	320.0	20.60
3	ROCKFILL	135.0	135.0	0.0[2]	36.0[2]	0.0[2]	36.0[2]	0.0[2]	36.0[2]	0.0[2]	36.00[2]
4	UPPER UNIT-ALLUVIUM	123.0	123.0	700.0	0.0	560.0	23.0	0.0	30.0	280.0	26.50
5	LOWER UNIT-ALLUVIUM	124.0	124.0	1100.0	0.0	1120.0	11.0	0.0	30.0	560.0	20.50
6	BERM FILL	109.0	122.0	500.0[2]	0.0[2]	500.0[2]	0.0[2]	0.0[2]	22.0[2]	250.0[2]	11.00[2]
7	SAND	130.0	130.0	0.0[2]	30.0[2]	0.0[2]	30.0[2]	0.0[2]	30.0[2]	0.0[2]	30.00[2]

1. THESE SOIL PARAMETERS ARE ASSUMED VALUES BASED ON REMOLDED SOIL TESTS, CONDUCTED FOR THE BURLINGTON DAM STUDY, DONE ON GLACIAL TILL.
2. ROCKFILL, BERM FILL, AND SAND PARAMETERS ARE ASSUMED VALUES.

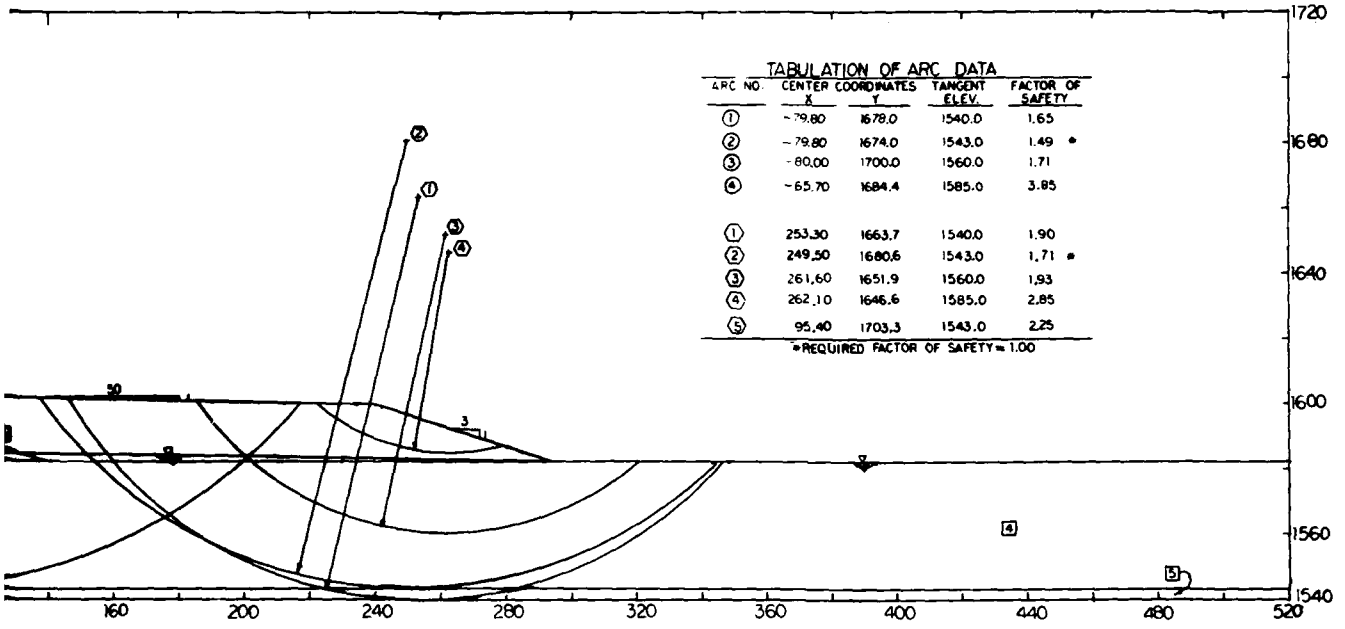


TABULATION OF ARC DATA

ARC NO	CENTER COORDINATES X	Y	TANGENT ELEV.	FACTOR OF SAFETY
①	-81.60	1658.2	1540.0	2.02
②	-81.80	1665.8	1543.0	1.83 *
③	-80.00	1700.0	1560.0	2.03
④	-69.30	1688.3	1585.0	4.38
①	260.60	1652.5	1540.0	2.34
②	259.70	1659.1	1543.0	2.15 *
③	262.60	1642.6	1560.0	2.26
④	261.60	1632.5	1585.0	3.13
⑤	79.10	1674.5	1543.0	3.17

*REQUIRED FACTOR OF SAFETY = 1.30

RUCTION



TABULATION OF ARC DATA

ARC NO.	CENTER COORDINATES X	Y	TANGENT ELEV.	FACTOR OF SAFETY
①	-79.80	1678.0	1540.0	1.65
②	-79.80	1674.0	1543.0	1.49 *
③	-80.00	1700.0	1560.0	1.71
④	-65.70	1684.4	1585.0	3.85
①	253.30	1663.7	1540.0	1.90
②	249.50	1680.6	1543.0	1.71 *
③	261.60	1651.9	1560.0	1.93
④	262.10	1646.6	1585.0	2.85
⑤	95.40	1703.3	1543.0	2.25

*REQUIRED FACTOR OF SAFETY = 1.00

UCTION W/EARTHQUAKE

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
ST PAUL, MINNESOTA

DESIGN MEMORANDUM NO 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
STABILITY ANALYSIS
END OF CONSTRUCTION AND END OF CONSTRUCTION WITH EARTHQUAKE

L.H.B.
L.H.B.
M.B.

SUBMITTED BY:

APPROVED:

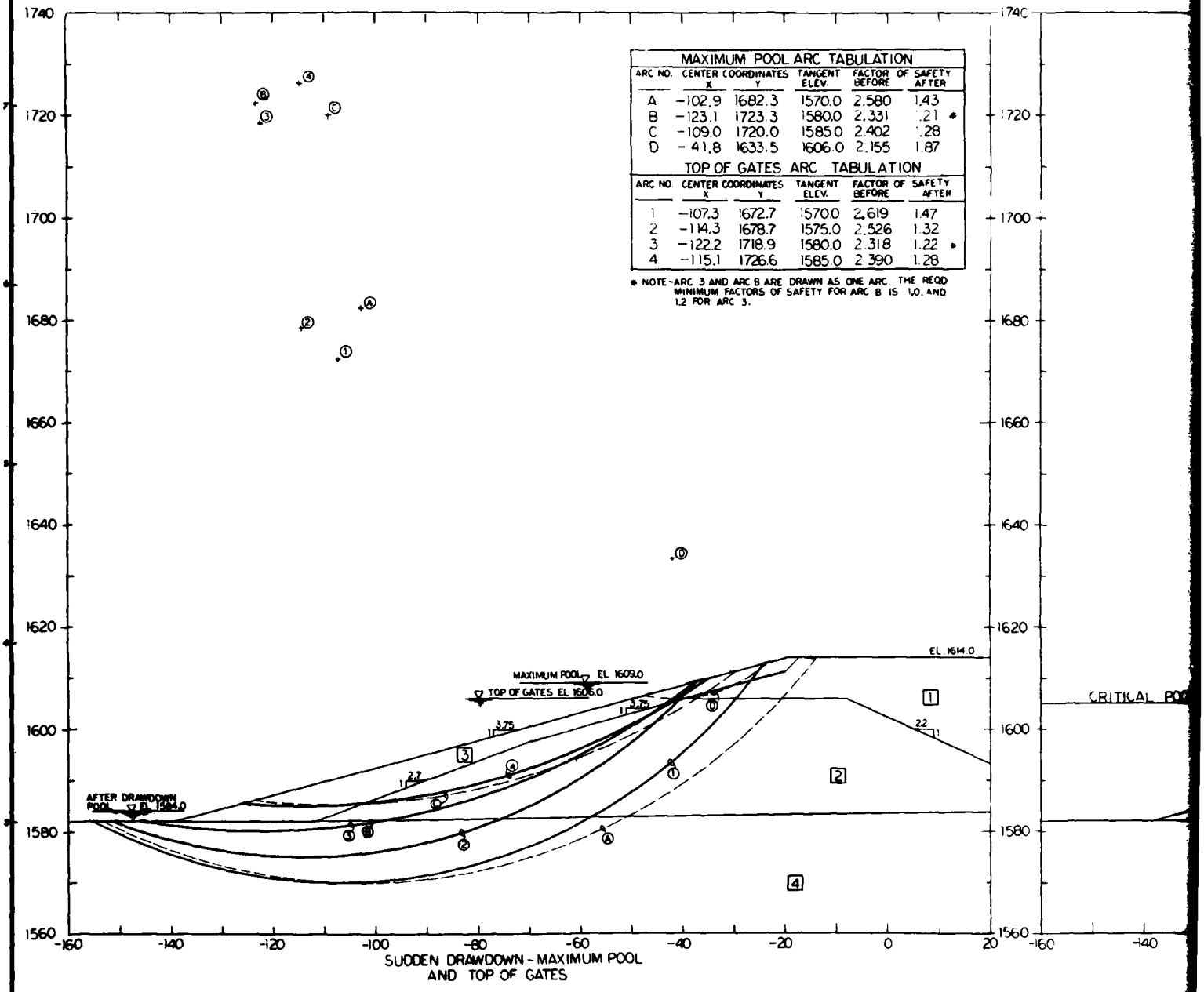
DATE: JUNE 1983

AS SHOWN

DRAWING NUMBER
R-RI-5/704

SHEET OF

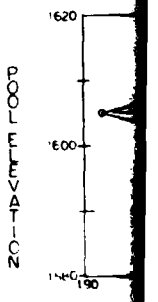
PLATE NO. B-5

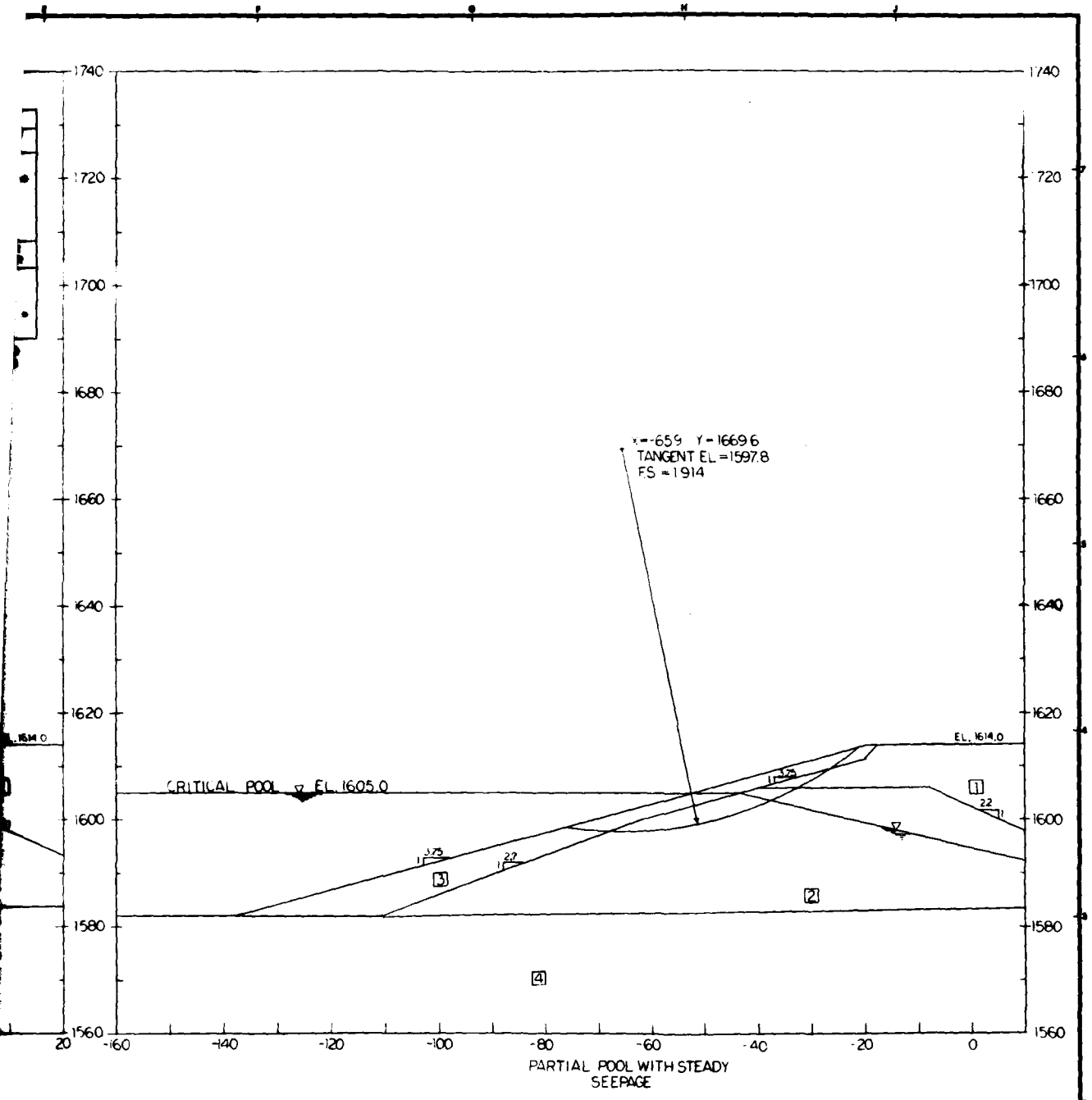


SUDDEN DRAWDOWN - MAXIMUM POOL AND TOP OF GATES

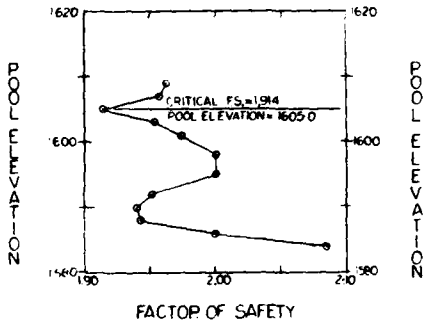
NOTES

1. REFERENCE PLATE B-5 – SOIL PARAMETERS





PARTIAL POOL WITH STEADY SEEPAGE



FACTOR OF SAFETY

SAFETY PAYS

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

DESIGN MEMORANDUM NO 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
STABILITY ANALYSIS
PARTIAL POOL, AND SUDDEN DRAWDOWN
FROM TOP OF GATES AND MAXIMUM POOL

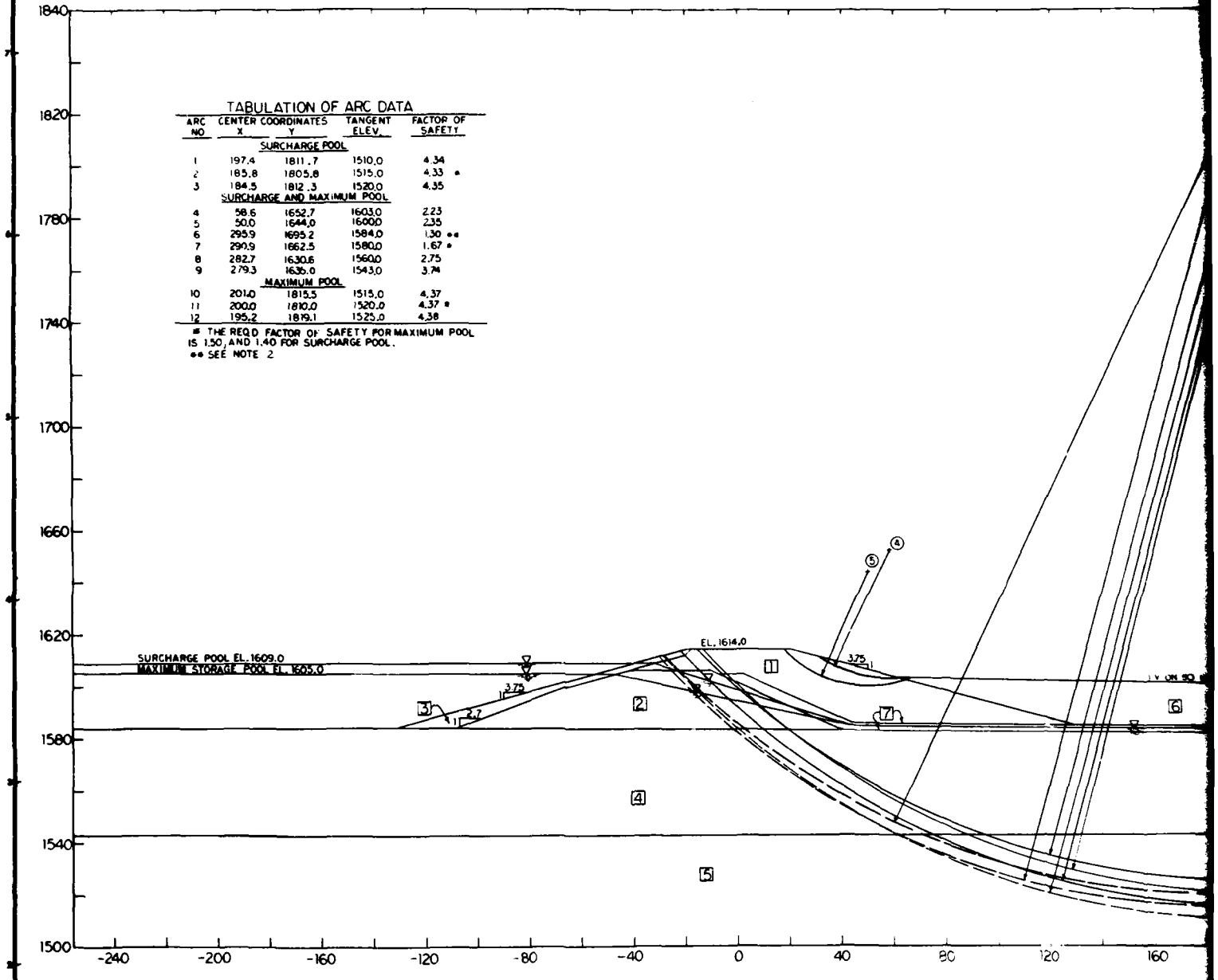
DESIGNED BY: L.H.B.
DRAWN BY: L.H.B.
TRACED BY: M.B.
SUBMITTED BY:
APPROVED:
DATE: JUNE 1963
SCALE: AS SHOWN
DRAWING NUMBER: R-RI-5/705
SHEET OF

PLATE NO. B-6

TABULATION OF ARC DATA

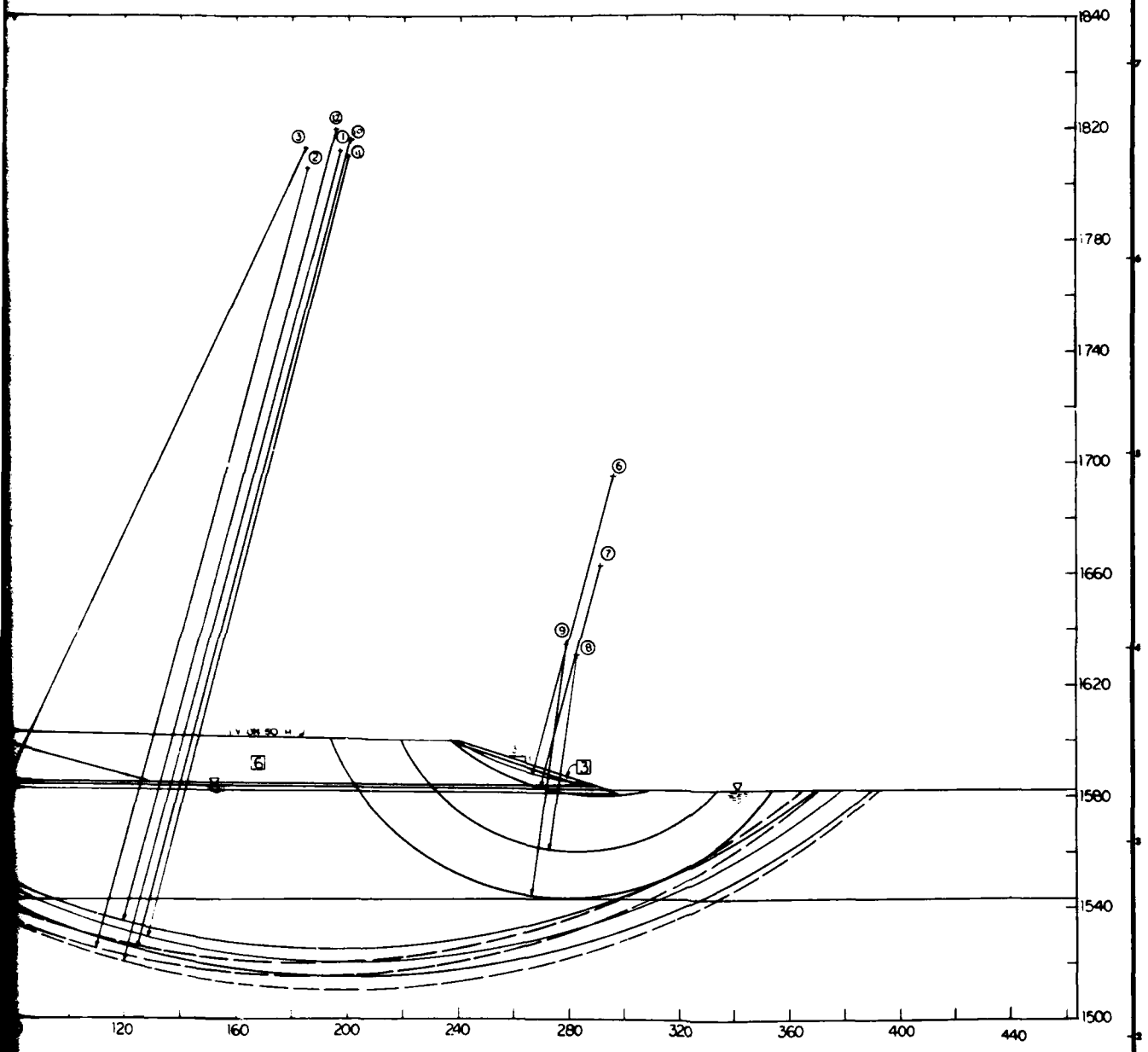
ARC NO	CENTER COORDINATES X	CENTER COORDINATES Y	TANGENT ELEV.	FACTOR OF SAFETY
		SURCHARGE POOL		
1	197.4	1811.7	1510.0	4.34
2	185.8	1805.8	1515.0	4.33 *
3	184.5	1812.3	1520.0	4.35
		SURCHARGE AND MAXIMUM POOL		
4	58.6	1652.7	1603.0	2.23
5	50.0	1644.0	1600.0	2.35
6	295.9	1695.2	1584.0	1.30 **
7	290.9	1662.5	1580.0	1.67 *
8	282.7	1630.6	1560.0	2.75
9	279.3	1636.0	1543.0	3.74
		MAXIMUM POOL		
10	201.0	1815.5	1515.0	4.37
11	200.0	1810.0	1520.0	4.37 *
12	195.2	1819.1	1525.0	4.38

* THE REQ'D FACTOR OF SAFETY FOR MAXIMUM POOL IS 1.50, AND 1.40 FOR SURCHARGE POOL.
** SEE NOTE 2



NOTES

1. REFERENCE PLATE B-5 FOR SOIL PARAMETERS.
2. ARC 6 DOES NOT MEET THE DESIGN CRITERIA FOR STEADY SEEPAGE STABILITY ANALYSIS, HOWEVER; IT IS A SHALLOW ARC IN A BERM WITH ASSUMED SOIL PARAMETERS, AND A FACTOR OF SAFETY OF 1.30 IS ACCEPTABLE FOR THE GIVEN CONDITIONS.



SYMBOL	DESCRIPTION	DATE	APPROVED

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

DESIGNED BY: L.H.B.
DRAWN BY: L.H.B.
TRACED BY: M.B.
SUBMITTED BY:

DESIGN MEMORANDUM NO. 5 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
STABILITY ANALYSIS-STEADY SEEPAGE
MAXIMUM STORAGE POOL AND SURCHARGE POOL

APPROVED:
DATE: JUNE 1983

SCALE: AS SHOWN
DRAWING NUMBER
R-RI-5/706
SHEET OF

SAFETY PAYS

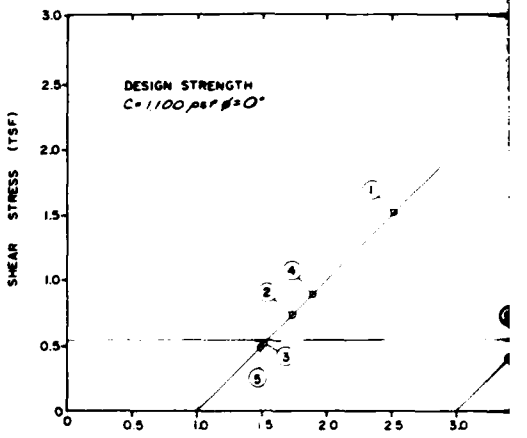
PLATE NO B-7

1

2

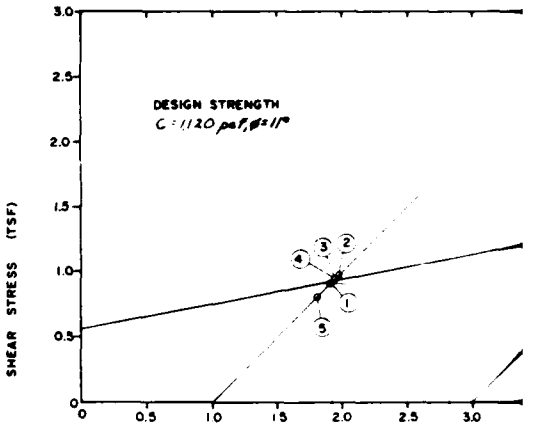
Q-TESTS

TEST NO	BORING NO	SAMPLE NO	% MOISTURE CONTENT	LIQUID LIMIT	PLASTIC LIMIT	AVERAGE VOID RATIO	% INITIAL SATURATION
①	74-62M	S-5	24.1	35	19	0.680	96.3
②	74-62M	S-6	25.1	31	17	0.660	100.0
③	74-62M	S-7	30.4	46	17	0.900	92.7
④	74-63M	S-21	23.7	23	19	0.643	98.7
⑤	76-81M	S-6	37.8	63	24	0.977	100.0



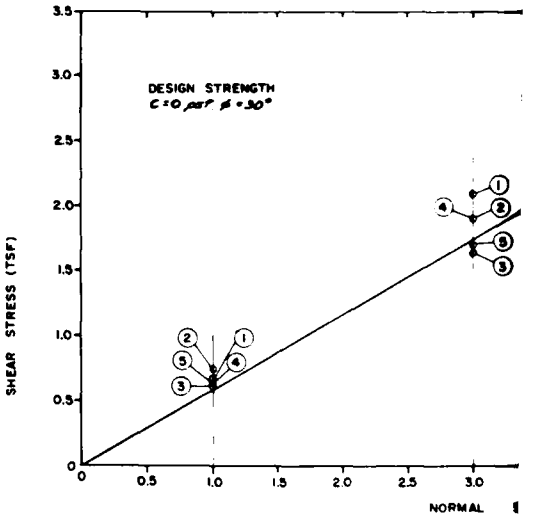
R-TESTS

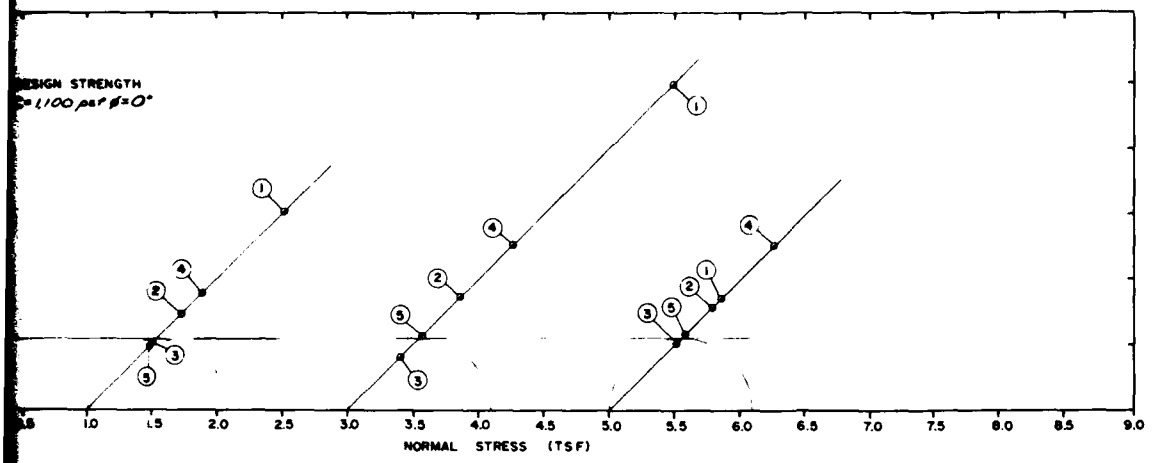
TEST NO	BORING NO	SAMPLE NO	% MOISTURE CONTENT	LIQUID LIMIT	PLASTIC LIMIT	AVERAGE VOID RATIO	% INITIAL SATURATION
①	74-62M	S-6	27.9	31	17	0.733	100.0
②	74-62M	S-7	29.3	46	17	0.820	98.7
③	74-63M	S-21	25.5	23	19	0.717	95.0
④	74-63M	S-29	25.4	22	18	0.748	95.3
⑤	76-81M	S-6	37.4	63	24	0.977	100.0

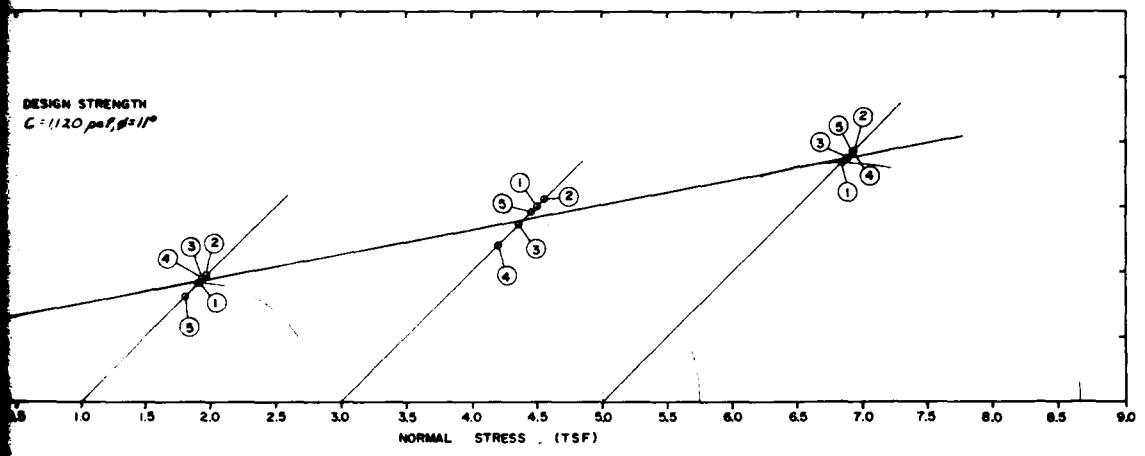


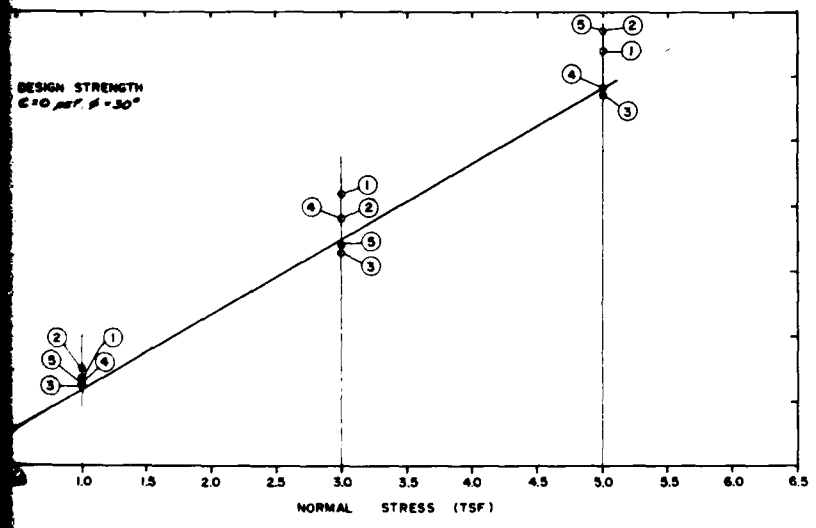
S-TESTS

TEST NO.	BORING NO.	SAMPLE NO.	% MOISTURE CONTENT	LIQUID LIMIT	PLASTIC LIMIT	AVERAGE VOID RATIO	% INITIAL SATURATION
①	74-62M	S-5	22.8	35	19	0.770	81.3
②	74-62M	S-6	24.9	31	17	0.733	88.0
③	74-62M	S-7	27.3	46	17	0.870	86.7
④	74-63M	S-21	24.7	23	19	0.687	96.7
⑤	74-63M	S-29	22.6	22	18	0.703	86.3









DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
ST PAUL, MINNESOTA

DESIGN MEMORANDUM NO. 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
LAKE DARLING DAM
FOUNDATION STRENGTHS
LOWER UNIT

DESIGNED BY: M. B
DRAWN BY: J.L.
TRACED BY: L.D.
SUBMITTED BY:
APPROVED:

DATE: JUNE 1963
SCALE: AS SHOWN
DRAWING NUMBER: RI-R-5/707
SHEET OF

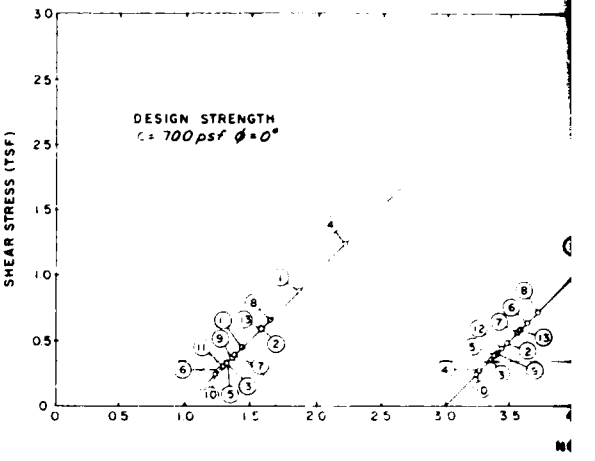
PLATE NO. B-8

SAFETY PAYS

1 2

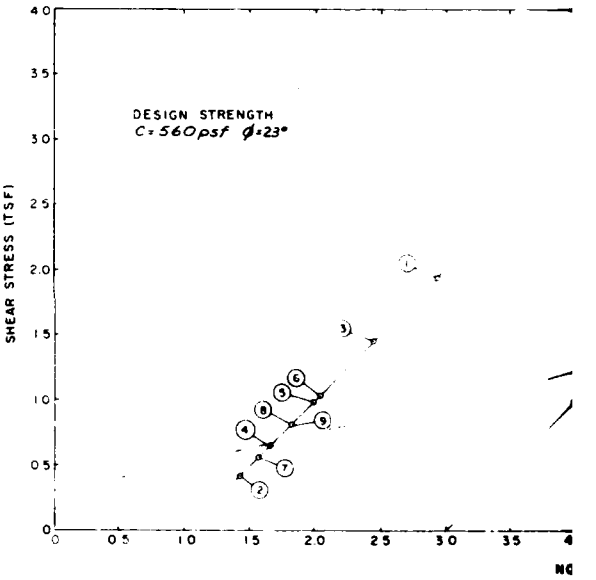
Q-TESTS

TEST NO	BORING NO.	SAMPLE NO	MOISTURE CONTENT %	LIQUID LIMIT	PLASTIC LIMIT	AVG VOIDS RATIO	INITIAL SATURATION %
1	74-62M	S-3	23.7	29	17	0.643	99.7
2	74-62M	S-4	25.3	25	19	0.670	99.7
3	74-63M	S-5	21.6	29	15	0.653	90.0
4	74-63M	S-8	16.9	24	19	0.495	92.0
5	74-63M	S-12	23.0	27	16	0.640	98.3
6	76-81M	S-1	39.6	34	17	1.163	90.3
7	76-81M	S-3	27.5	29	15	0.787	93.3
8	76-81M	S-4	30.2	50	22	0.850	94.3
9	76-93M	S-1	27.5	50	19	0.753	98.0
10	76-93M	S-2	27.3	26	14	0.767	98.3
11	76-93M	S-3	21.2	24	13	0.577	97.3
12	76-93M	S-4	32.7	45	19	0.860	100.0
13	76-93M	S-5	22.4	25	13	0.567	100.0



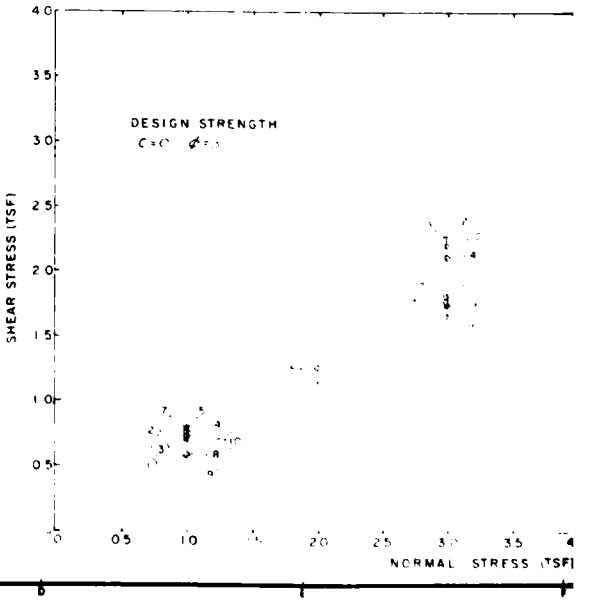
R-TESTS

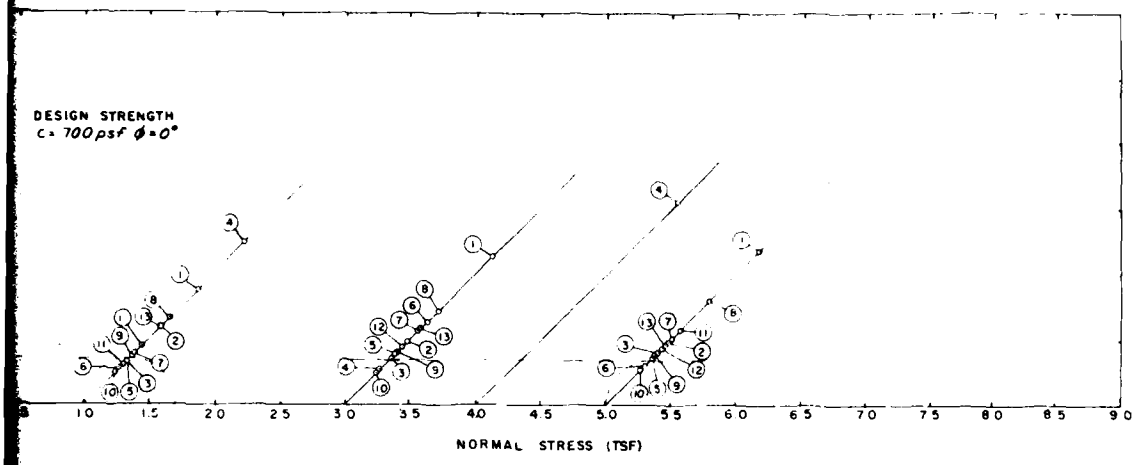
TEST NO.	BORING NO	SAMPLE NO.	MOISTURE CONTENT %	LIQUID LIMIT	PLASTIC LIMIT	AVG. VOIDS RATIO	INITIAL SATURATION %
1	74-62M	S-3	24.1	29	17	0.635	100.0
2	74-63M	S-5	21.7	29	15	0.657	90.3
3	74-63M	S-12	22.6	27	16	0.627	98.0
4	76-81M	S-1	47.3	34	17	1.350	90.3
5	76-81M	S-2	28.0	45	24	0.880	88.3
6	76-81M	S-3	26.2	27	15	0.677	100.0
7	76-81M	S-4	37.7	44	21	1.027	98.7
8	76-81M	S-5	29.0	43	17	0.780	100.0
9	76-93M	S-2	27.6	26	14	0.653	100.0

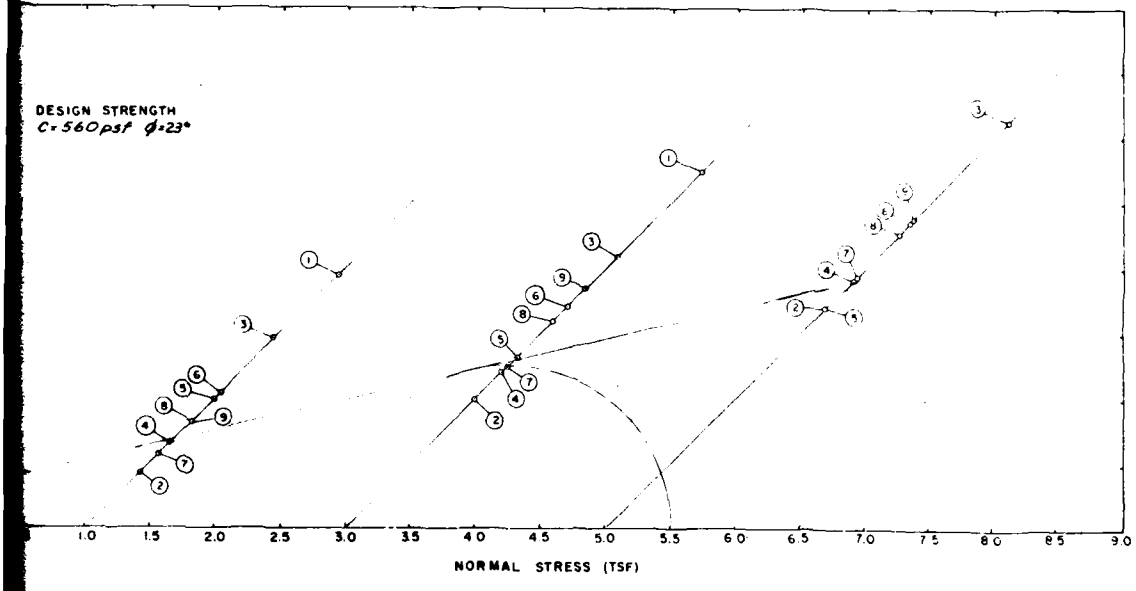


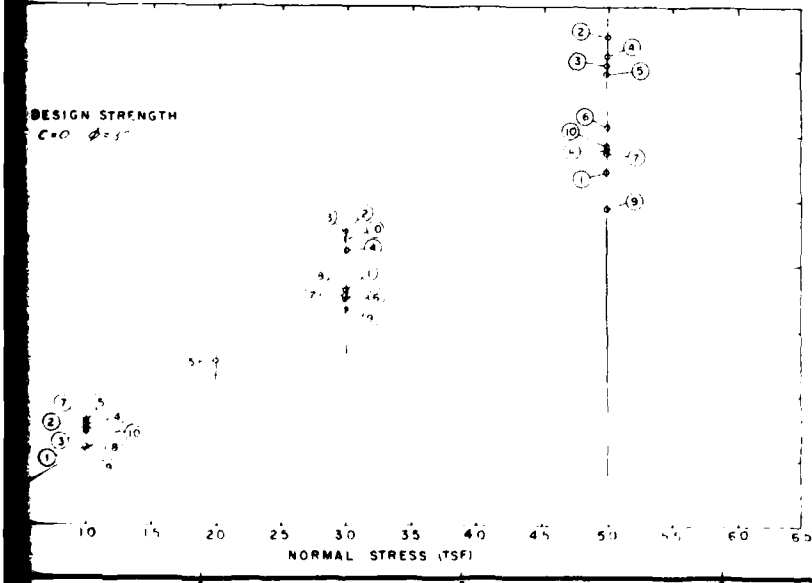
S-TESTS

TEST No.	BORING NO	SAMPLE NO.	MOISTURE CONTENT %	LIQUID LIMIT	PLASTIC LIMIT	AVG VOIDS RATIO	INITIAL SATURATION %
1	74-62M	S-3	24.8	29	17	0.687	97.0
2	74-62M	S-4	18.5	25	19	0.560	86.7
3	74-63M	S-8	19.8	24	19	0.617	86.7
4	74-63M	S-12	21.3	27	16	0.610	96.3
5	74-63M	S-15	20.3	25	18	0.567	96.3
6	76-81M	S-1	29.2	34	17	0.913	85.7
7	76-81M	S-2	29.7	45	24	0.990	82.3
8	76-81M	S-4	31.2	50	22	1.017	81.7
9	76-93M	S-1	27.9	50	19	0.807	94.0
10	76-93M	S-2	25.0	26	14	0.750	88.0









SAFETY PAYS

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT CORPS OF ENGINEERS
ST PAUL MINNESOTA

DESIGNED BY M B
DRAWN BY A P
CHECKED BY L D
SUBMITTED BY
APPROVED

DESIGN MEMORANDUM NO 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
LAKE DARLING DAM
FOUNDATION STRENGTHS
UPPER UNIT

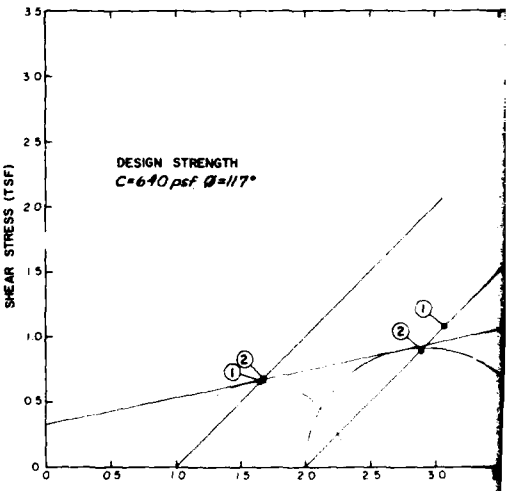
DATE
JUNE 1983
AS SHOWN
DRAWING NUMBER
RI-R-5/708
SHEET OF

PLATE NO 8-9

1 2

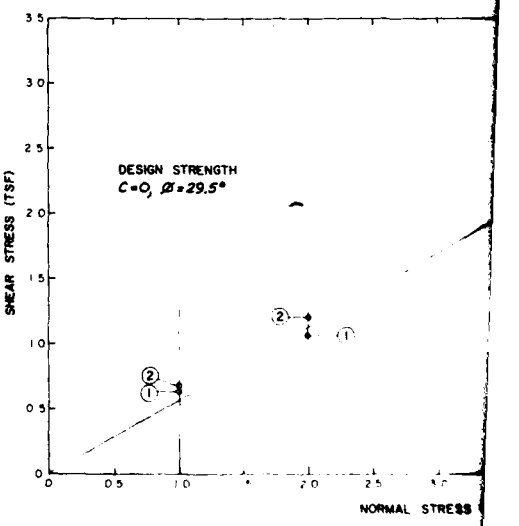
R-TESTS

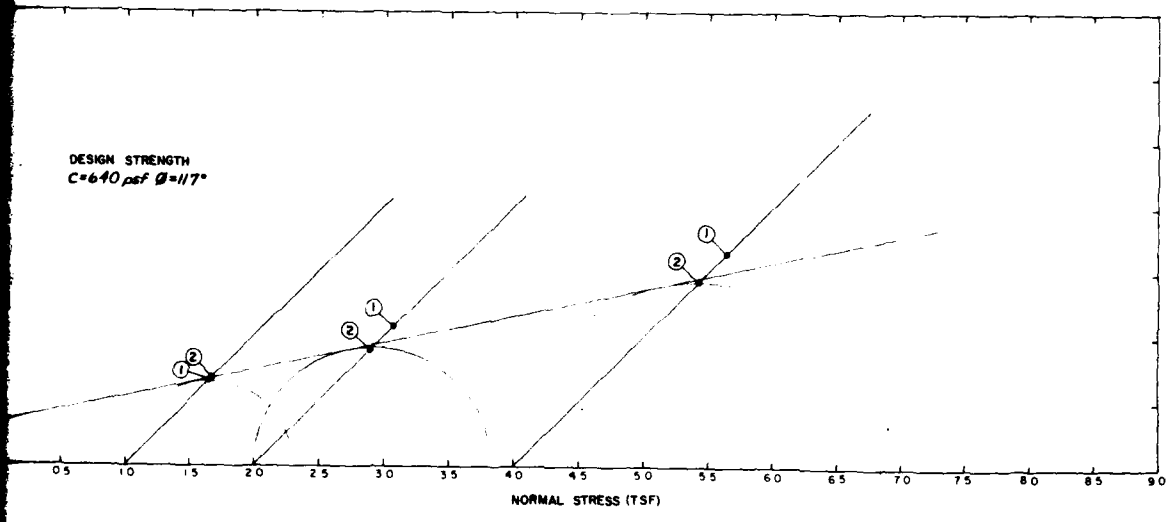
TEST NO.	BORING NO	SAMPLE NO	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	VOID RATIO	INITIAL SATURATION (%)
1	74-62M	1	19.9	41	15	0.637	83.3
2	74-62M	2	25.4	45	19	0.857	79.7

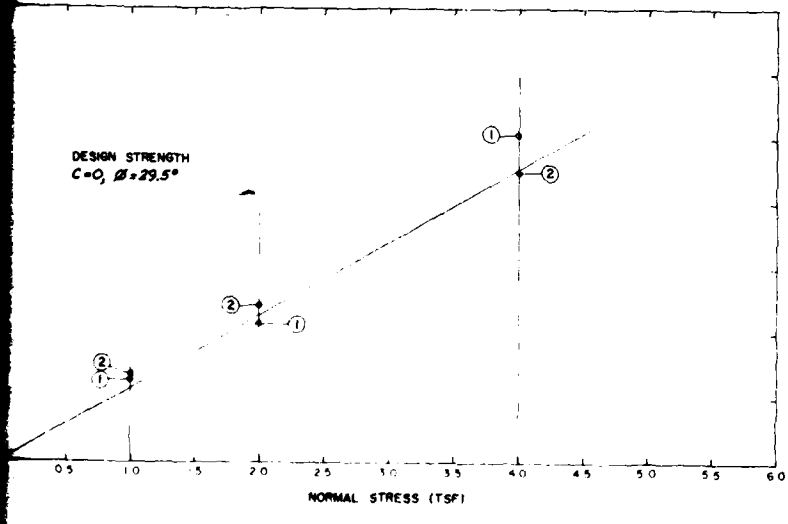


S-TESTS

TEST NO.	BORING NO	SAMPLE NO	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	VOID RATIO	INITIAL SATURATION (%)
1	74-62M	1	19.4	41	15	0.773	67.3
2	74-62M	2	20.9	45	19	0.700	81.7







SAFETY PAYS

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT CORPS OF ENGINEERS
ST PAUL MINNESOTA

SUPERVISED BY	M B
DRAWN BY	L M P
CHECKED BY	L D
SUBMITTED BY	
APPROVED	

DESIGN MEMORANDUM NO 5 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
LAKE DARLING DAM
EXISTING EMBANKMENT
UNDISTURBED R AND S TESTS

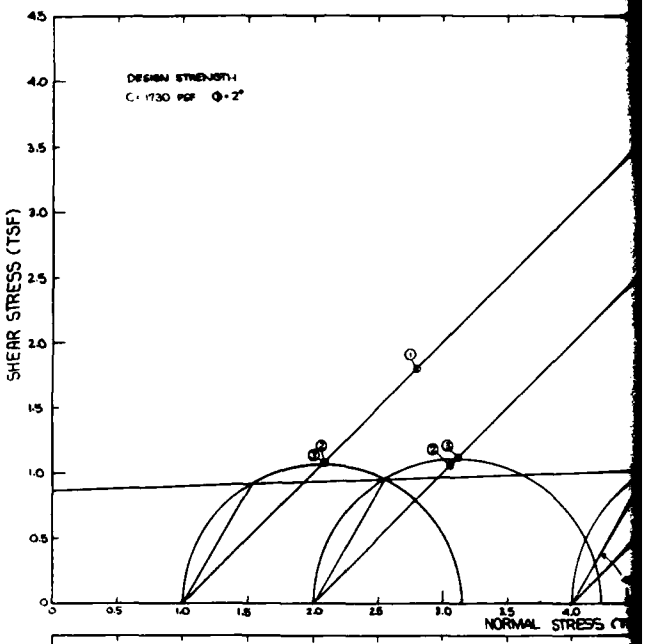
DATE
JUNE 1983

SCALE AS SHOWN
DRAWING NUMBER
RI-R-5/709
SHEET OF

PLATE NO B-10

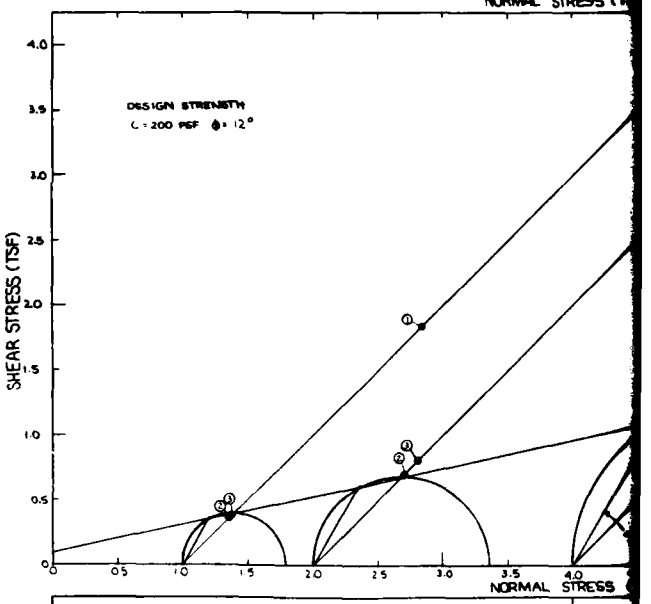
Q-TEST

TEST NO.	BORING NO.	SAMPLE NO.	LIQUID LIMIT	PLASTIC LIMIT	OPTIMUM M.C. (%)	SAMPLE M.C. (%)
①	78-117M	13+14	26	14	8.1	8.0
②	78-117M	15+16	42	14	15.5	15.1
③	78-117M	17+18+19	41	27	15.3	15.6



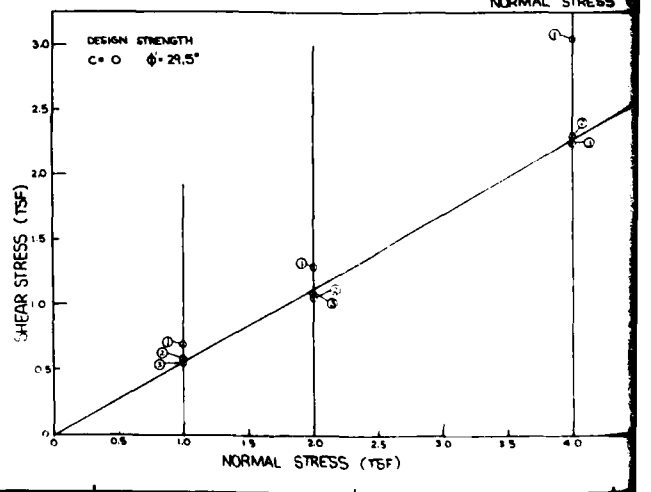
R-TEST

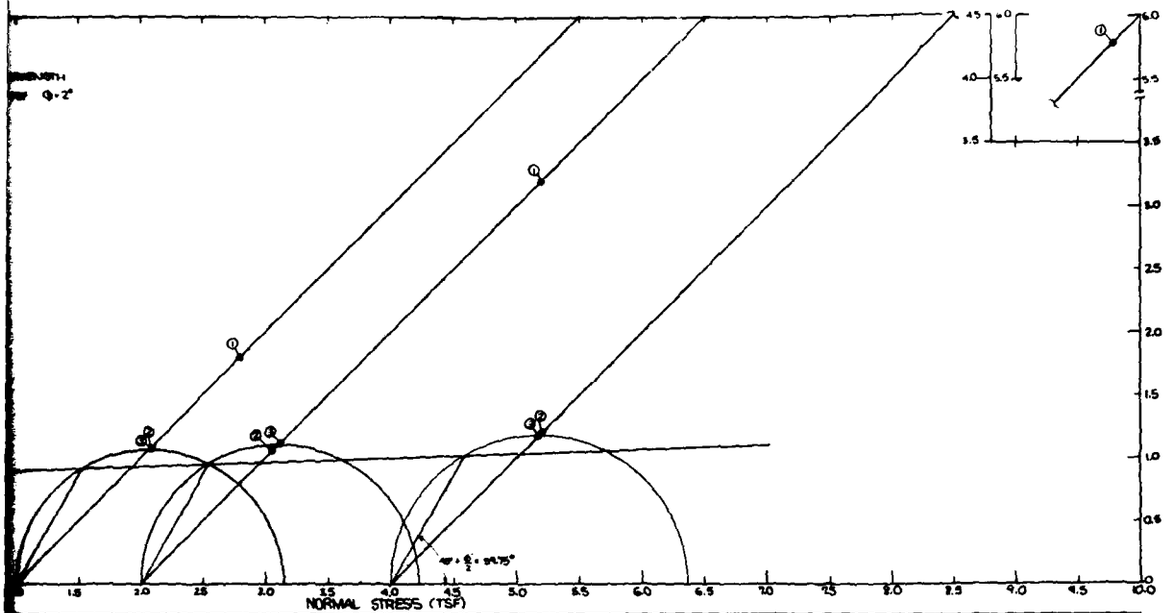
TEST NO	BORING NO.	SAMPLE NO.	LIQUID LIMIT	PLASTIC LIMIT	OPTIMUM M.C. (%)	SAMPLE M.C. (%)
①	78-117M	13+14	26	14	8.1	8.3
②	78-117M	15+16	42	14	15.5	15.4
③	78-117M	17+18+19	41	27	15.3	16.2

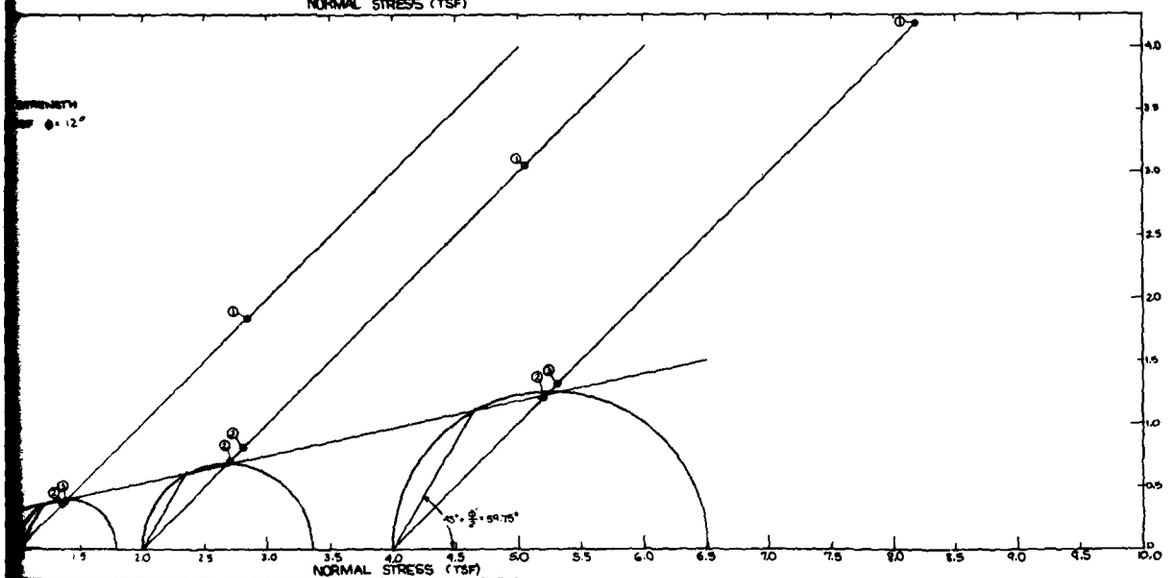


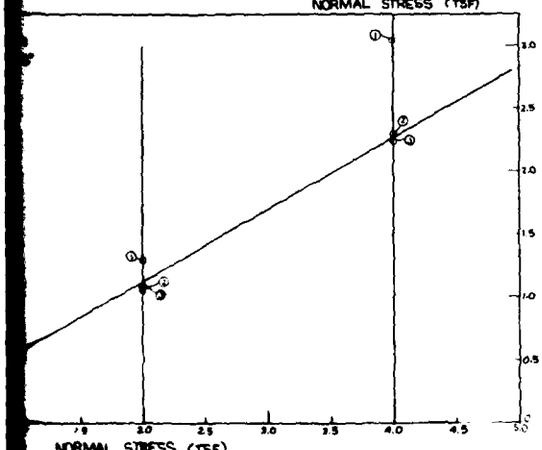
S-TEST

TEST NO	BORING NO.	SAMPLE NO.	LIQUID LIMIT	PLASTIC LIMIT	OPTIMUM M.C. (%)	SAMPLE M.C. (%)
①	78-117M	13+14	26	14	8.1	8.3
②	78-117M	15+16	42	14	15.5	15.9
③	78-117M	17+18+19	41	27	15.3	16.7









NOTES

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
ST PAUL, MINNESOTA

DESIGN MEMORANDUM NO 3 GENERAL

FLOOD CONTROL – LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

LAKE DARLING DAM
NEW EMBANKMENT FILL
REMOLDED Q, R, AND S, TESTS

DESIGNED BY: LHB
DRAWN BY: LHB
TRACED BY: L.D.
SUBMITTED BY:

APPROVED:

DATE: JUNE 1983

DRAWING NUMBER
RI-R-5/710

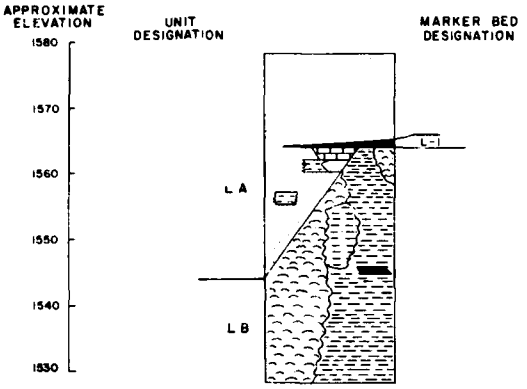
SHEET OF

PLATE NO. B-11

LAKE DARLING DAMSITE

TONGUE RIVER FORMATION

PRELIMINARY GFOLOGIC COLUMN, LEFT ABUTMENT



LEGEND

SHALE (CLAY)

MATERIAL CLASSIFIED AS SHALE CONSISTS PREDOMINENTLY OF CLAY-SIZED PARTICLES AND VARIES FROM A CLAY WITH NO APPARENT SHALE STRUCTURE TO AN INDURATED CLAY WITH SLIGHT FISSILITY OR SHALE STRUCTURE. THE FRESH MATERIAL IS GENERALLY MASSIVE IN APPEARANCE, BUT MAY CONTAIN SILT OR FINE SAND LAMINAE. WHEN THESE LAMINAE DOMINATE, THE MATERIAL IS CLASSIFIED AS LAMINATED SILTSTONE. THE FRESH SHALE IS GENERALLY SOFT TO VERY SOFT, MOIST, SLIGHTLY BRITTLE, DK GRAY TO BLACK AND OFTEN CONTAINS CARBONACEOUS INCLUSIONS AND LIGNITE FRAGMENTS. THE FRESH MATERIAL IS GLOSSY WHEN SCRAPED WITH A KNIFE. THE DRIED MATERIAL IS MODERATELY HARD, VERY BRITTLE AND LT GRAY. THE MATERIAL SLAKES SLOWLY WHEN IMMERSED IN WATER. SLAKING RATE INCREASES WITH AN INCREASE IN SILT LAMINAE.

LAMINATED SILTSTONE

MATERIAL CLASSIFIED AS LAMINATED SILTSTONE IS GRADATIONAL BETWEEN SHALE AND HOMOGENEOUS SILTSTONE. SILT LAMINAE AND THIN SEAMS UP TO A FEW INCHES THICK PREDOMINATE, BUT ARE INTERBEDDED WITH CLAY AND CLAYEY FINE SAND. THE FRESH MATERIAL IS GENERALLY SOFT, MOIST, FRIABLE IN SILT SEAMS AND BRITTLE IN CLAY LAMINAE, BROWN OR GRAY AND OFTEN CONTAINS CARBONACEOUS INCLUSIONS AND LIGNITE FRAGMENTS. UPON DRYING, THE MATERIAL BECOMES MODERATELY HARD WITH A CHALKY TO FRIABLE SURFACE. DRIED PIECES CAN BE BROKEN EASILY BY HAND. THE FRESH MATERIAL IS VARIABLY DULL AND GLOSSY WHEN SCRAPED WITH A KNIFE. THE MATERIAL SLAKES RAPIDLY WHEN IMMERSED IN WATER.

HOMOGENEOUS SILTSTONE

MATERIAL CLASSIFIED AS HOMOGENEOUS SILTSTONE CONTAINS SIGNIFICANT PROPORTIONS OF SILT AND CLAY, BUT THE CONSTITUENT MATERIALS FORM A HOMOGENEOUS MASS RATHER THAN CONSPICUOUS SEAMS OR LAMINAE. THE FRESH MATERIAL IS GENERALLY VERY SOFT, VARIES FROM FRIABLE TO FRIABLE WITH SLIGHT PLASTICITY, DK BROWN AND GRAY AND OFTEN CONTAINS AN ABUNDANCE OF CARBONACEOUS INCLUSIONS AND LIGNITE FRAGMENTS. THE FRESH MATERIAL IS DULL WHEN SCRAPED WITH A KNIFE. UPON DRYING, THE MATERIAL BECOMES MODERATELY HARD WITH A CHALKY, FRIABLE SURFACE. DRIED PIECES ARE DIFFICULT TO BREAK BY HAND. THE MATERIAL SLAKES SLOWLY WHEN IMMERSED IN WATER.

SANDSTONE

MATERIAL CLASSIFIED AS SANDSTONE VARIES FROM VERY FINE TO MEDIUM GRAINED AND IS GENERALLY SILTY OR CLAYEY. THE FRESH MATERIAL IS GENERALLY VERY SOFT, NON-CEMENTED, FRIABLE, MUCH TO WET AND BROWN IN HUE. THE SANDSTONE VARIES FROM A HOMOGENEOUS MASS WITH NO PERCEPTIBLE BEDDING TO THIN BEDDED OR CROSS BEDDED OCCASIONAL SILT OR CLAY SEAMS. CARBONACEOUS INCLUSIONS AND LIGNITE FRAGMENTS ARE COMMON. THE DRIED MATERIAL IS MODERATELY HARD WITH A FRIABLE SURFACE. DRIED PIECES CAN BE BROKEN BY HAND WITH MODERATE PRESSURE. THE MATERIAL SLAKES SLOWLY WHEN IMMERSED IN WATER.

CEMENTED SANDSTONE

MATERIAL CLASSIFIED AS CEMENTED SANDSTONE IS SIMILAR TO THE OTHER SANDSTONE EXCEPT IT OCCURS IN THIN BEDS, IS HARD AND CEMENTED WITH SILICA.

LIGNITE

MATERIAL CLASSIFIED AS LIGNITE IS CARBONIZED WOOD OR OTHER VEGETAL MATTER. THE LIGNITE IS MODERATELY HARD TO HARD, BRITTLE, OFTEN PLATY OR FRACTURED AND BROWN OR BLACK. THE LIGNITE OCCURS IN BEDS THAT PERSIST OVER CONSIDERABLE AREA, DISCONTINUOUS SEAMS, LENSES AND RANDOMLY ORIENTED FRAGMENTS. THE FRACTURED LIGNITE SEAMS ARE WATER BEARING IN WHICH DRILLING FLUID LOSS OCCURS AND SOFT SEEPS OR SPRINGS IN OUTCROP AREAS.

CARBONATE CONCRETION

MATERIAL SHOWN IN THE BORING LOGS AS LIMESTONE IS INTERPRETED TO BE CARBONATE CONCRETIONS. MANY SUCH CONCRETIONS ARE EXPOSABLE IN OUTCROP AREAS. CONCRETIONS UP TO 3 FEET THICK AND 6 FEET LONG HAVE BEEN OBSERVED.

EXPLANATION OF GEOLOGIC COLUMNS

THE GEOLOGIC [illegible] OF THE TONGUE RIVER FORMATION FROM VISUAL INSPECTION OF CORE SAMPLES TAKEN AT THE DAM SITE. APPLICABLE ONLY TO THE IMMEDIATE AREAS INDICATED. THE COLUMNS ARE THE RESULTS OF A PRELIMINARY ATTEMPT AT SYSTEMATIC CORRELATION OF THE STRATA. INTENDED TO SERVE AS A BASE FROM WHICH ON FORMITY IS TO BE ESTABLISHED. THIS CAN BE ACCOMPLISHED. THE ELEVATIONS SHOWN ARE APPROXIMATE, AND A BED AT ANY GIVEN LOCATION MAY VARY CONSIDERABLY FROM THAT SHOWN.

THE TONGUE RIVER FORMATION IS A TERRESTRIAL DEPOSIT KNOWN LATERALLY AS WELL AS VERTICALLY. THIS CHARACTERISTIC IS READILY APPARENT UPON INSPECTION OF THE OUTCROPS. THE WATER AND UNDOUBTEDLY MORE LIMITED AREA OF THE DAMSITE THAN THE COLUMNS INDICATE. THIS APPARENT EXAGGERATION OF VARIABILITY STEMS FROM THE FACT THAT THE LITHOLOGIC UNITS - SHALE, LAMINATED SILTSTONE, HOMOGENEOUS SILTSTONE AND LIGNITE EACH UNIT, EXCEPT LIGNITE CONTAINS A WIDE RANGE OF MATERIALS. ALMOST IMPERCEPTIBLY INTO ADJACENT WITH LOGICAL TERMS FOR EXAMPLE WITH A HIGH CLAY CONTENT GRADES INTO SHALE AT ONE EXTREME, BUT AT THE OTHER WITH LITTLE CLAY OR SILT MAY GRADES INTO HOMOGENEOUS SILTSTONE. SINCE THE CLASSIFICATIONS ARE BASED ON VISUAL INSPECTION, INCONSISTENCIES OF BORDER LINE MATERIALS IS UNAVOIDABLE. IF THESE AREAS ARE VIEWED AS BEING OF GRADATIONAL UNIT BOUNDARYS AND OVERLAPPING CLASSIFICATIONS THEY BECOME LESS CONFUSING.

LEGEND FOR BOR

TONGUE RIVER FM

- SHALE
- LAMINATED SILTSTONE
- HOMOGENEOUS SILTSTONE
- SANDSTONE
- CEMENTED SANDSTONE
- LIGNITE
- CARBONATE CONCRETIONS

THE SYMBOLS SHOWN IN THE BORING STAFF RELATE THE BORINGS TO THE GENERAL CLASSIFICATIONS SHOWN ON THE GEOLOGIC COLUMNS. DESCRIPTIONS ARE SHOWN ON THE BORING STAFF.

- NATURAL BREAKS IN THE CORE. NUMBER IN PARENTHESIS INDICATES CLOSELY SPACED BREAKS.
- LOCATION OF JOINT WITH DEGREE OF DIP.
- LOCATION OF SLICKENSIDE WITH DEGREE OF DIP.
- FRACTURED ZONE
- ZONE OF LOST CORE
- L-5 MARKER BED IDENTIFICATION
- LD UNIT DESIGNATION

GENERAL NOTES

1 PERCENT CORE RECOVERY IS SHOWN TO THE LEFT OF THE BORING STAFF. UNLESS SPECIFIED OTHERWISE, ALL CORE IS 4-INCH DIAMETER.

2 ROCK QUALITY DESIGNATION, RQD, IS SHOWN TO THE LEFT OF THE PERCENT RECOVERY COLUMN. RQD IS THE PERCENT RECOVERY CONSISTING OF UNFRACTURED PIECES GREATER THAN 0.3 FOOT IN LENGTH.

3 NOTES PERTAINING TO A SPECIFIC BORING ARE SHOWN BELOW THE BORING STAFF.

4 NOTES PERTAINING TO ALL BORINGS IN A SERIES OF BORINGS ARE SHOWN ON THE SHEET WITH THE FIRST BORING OF THAT SERIES.

DEFINITIONS OF TERMS USED ON THE BORING LOGS

THE TONGUE RIVER FORMATION IS AN "IMMATURE" ROCK THAT EXHIBITS BOTH ROCK AND SOIL CHARACTERISTICS. ROCK TERMS SUCH AS SANDSTONE, SILTSTONE AND SHALE ARE USED IN THE BORING LOGS RATHER THAN THE EQUIVALENT SOIL TERMS. THE CHOICE OF TERMS IS BASED ON PRECEDENCE ESTABLISHED IN THE LITERATURE AND OTHER CORPS OF ENGINEERS' PROJECTS.

BEDDING CHARACTERISTICS

HOMOGENEOUS - CONSTITUENT PARTICLES FORM A UNIFORM MASS CHARACTERIZED BY A LACK OF APPARENT BEDDING OR STRATIFICATION AND SUCH MATERIALS ARE GENERALLY CLASSIFIED HOMOGENEOUS.

LAMINATED - COMPONENT BEDS GENERALLY LESS THAN ½ INCH THICK CLASSIFIED AS LAMINATED ALTHOUGH MANY BEDS EXTENDED THE LIMITING THICKNESS.

VERY THIN BEDDED - COMPONENT BEDS ½ TO 2 INCHES THICK.
THIN BEDDED - COMPONENT BEDS 2 TO 6 INCHES THICK.
MEDIUM BEDDED - COMPONENT BEDS 2 TO 6 FEET THICK.
THICK BEDDED - COMPONENT BEDS 6 TO 8 FEET THICK.
MASSIVE - COMPONENT BEDS OVER 8 FEET THICK.

HARDNESS AND DEGREE OF CEMENTATION

PLASTIC - CAN BE EASILY DEFORMED WITH FINGERS.
FRIABLE - CAN BE EASILY CRUMBLED WITH FINGERS.
BRITTLE - CAN BE EASILY BROKEN WITHOUT DIFFICULTY.
VERY SOFT - CAN BE EASILY SCRATCHED WITH FINGER NAIL.
SOFT - CAN BE EASILY SCRATCHED WITH FINGER NAIL.
MODERATELY HARD - CAN BE EASILY SCRATCHED WITH KNIFE BLADE OR SCRATCHED WITH FINGER NAIL.
NON-CEMENTED - NO CEMENTING AGENT BINDS PARTICLES TOGETHER.
POORLY CEMENTED - CAN BE CRUSHED OR BROKEN WITH LITTLE DIFFICULTY.
MODERATELY CEMENTED - CAN BE CRUSHED OR BROKEN WITH DIFFICULTY.
WELL CEMENTED - CANNOT BE BROKEN BY HAND.

EXPLANATION OF GEOLOGIC COLUMNS

THE GEOLOGIC COLUMNS OF THE TONGUE RIVER FORMATION WERE DEVELOPED ENTIRELY FROM A VISUAL INSPECTION OF CORE SAMPLES TAKEN AT THE BURLINGTON DAMSITE AND ARE APPLICABLE ONLY TO THE IMMEDIATE AREAS INDICATED. THE COLUMNS WERE DEVELOPED AS PART OF A PRELIMINARY ATTEMPT AT SYSTEMATIC CORRELATION OF THE SITE BORINGS. THEY ARE ALSO INTENDED TO SERVE AS A BASE FROM WHICH UNIFORMITY IN SUBSEQUENT CLASSIFICATIONS CAN BE ACCOMPLISHED. THE ELEVATIONS SHOWN ARE APPROXIMATE, AND THE ACTUAL OCCURRENCE OF A BED AT ANY GIVEN LOCATION MAY VARY CONSIDERABLY FROM THAT SHOWN IN THE COLUMNS.

THE TONGUE RIVER FORMATION IS A TERRESTRIAL DEPOSIT KNOWN TO BE HIGHLY VARIABLE LATERALLY AS WELL AS VERTICALLY. THIS CHARACTERISTIC IS READILY APPARENT FROM A CASUAL INSPECTION OF THE COLUMNS. THE MATERIALS ARE UNDOUBTEDLY MORE UNIFORM WITHIN THE LIMITED AREA OF THE DAMSITE THAN THE COLUMNS INDICATE. THE COLUMNS' APPARENT EXAGGERATION OF VARIABILITY STEMS FROM THE FACT THAT THEY SHOW ONLY FIVE BASIC LITHOLOGIC UNITS - SHALE, LAMINATED SILTSTONE, HOMOGENEOUS SILTSTONE, SANDSTONE AND LIGNITE. EACH UNIT, EXCEPT LIGNITE, CONTAINS A WIDE RANGE OF MATERIALS WHICH GRADES ALMOST IMPERCEPTIBLY INTO ADJACENT LITHOLOGIC UNITS. FOR EXAMPLE, A LAMINATED SILTSTONE WITH A HIGH CLAY CONTENT GRADES INTO SHALE AT ONE EXTREME, BUT A LAMINATED SILTSTONE WITH LITTLE CLAY OR STRUCTURE GRADES INTO HOMOGENEOUS SILTSTONE AT THE OTHER EXTREME. SINCE THE CLASSIFICATION IS BASED ON VISUAL INSPECTION, INCONSISTENCY IN CLASSIFICATION OF BORDER LINE MATERIALS IS UNAVOIDABLE. IF THE COLUMNS ARE VIEWED WITH THE CONCEPTS OF GRADATIONAL UNIT BOUNDARYS AND OVERLAPPING CLASSIFICATIONS IN MIND, THEY BECOME LESS CONFUSING.

LEGEND FOR BORING LOGS

TONGUE RIVER FM

- SHALE
- LAMINATED SILTSTONE
- HOMOGENEOUS SILTSTONE
- SANDSTONE
- CEMENTED SANDSTONE
- LIGNITE
- CARBONATE CONCRETIONS

THE SYMBOLS SHOWN IN THE BORING STAFF RELATE THE BORING TO THE GENERAL CLASSIFICATION SYSTEM SHOWN ON THE GEOLOGIC COLUMNS. DETAILED DESCRIPTIONS ARE SHOWN TO THE RIGHT OF THE BORING STAFF.

- NATURAL BREAKS IN THE CORE
- (4) NUMBER IN PARENTHESIS INDICATES CLOSELY SPACED BREAKS.
- LOCATION OF JOINT WITH DEGREE OF DIP.
- LOCATION OF SLICKENSIDE WITH DEGREE OF DIP.
- FRACTURED ZONE
- ZONE OF LOST CORE
- L-5 MARKER BED IDENTIFICATION
- LD UNIT DESIGNATION

SOILS
(UNIFIED SOIL CLASSIFICATION SYSTEM)

- GW — WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
- GP — POORLY-GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.
- GM — SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURE.
- GC — CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURE.
- SW — WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES.
- SP — POORLY-GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES
- SM — SILTY SANDS, SAND-SILT MIXTURE.
- SC — CLAYEY SANDS, SAND-CLAY MIXTURES.
- ML — INORGANIC SILTS, LIQUID LIMIT LESS THAN 50.
- CL — INORGANIC CLAYS, LIQUID LIMIT LESS THAN 50
- MH — INORGANIC SILTS, LIQUID LIMIT GREATER THAN 50.
- CH — INORGANIC CLAYS, LIQUID LIMIT GREATER THAN 50.
- OL — ORGANIC SILTS OR CLAYS, LIQUID LIMIT LESS THAN 50
- OH — ORGANIC SILTS OR CLAYS, LIQUID LIMIT GREATER THAN 50.
- PT — PEAT
- SP/SM — BORDERLINE MATERIAL
- SC/CL — STRATIFIED MATERIAL
- WATER LEVEL — WATER LEVEL ON DATE OF BORING
- Xcp — SOIL IDENTIFICATION MADE FROM MACHINE ACTION AND DRILL CUTTINGS.

74-BM MACHINE BORING
74-TP TEST PIT

GENERAL NOTES

1 PERCENT CORE RECOVERY IS SHOWN TO THE LEFT OF THE BORING STAFF UNLESS SPECIFIED OTHERWISE, ALL CORE IS 4-INCH DIAMETER.

2 ROCK QUALITY DESIGNATION, RQD, IS SHOWN TO THE LEFT OF THE PERCENT RECOVERY COLUMN. RQD IS THE PERCENT RECOVERY CONSISTING OF UNFRACTURED PIECES GREATER THAN 0.3 FOOT IN LENGTH.

3 NOTES PERTAINING TO A SPECIFIC BORING ARE SHOWN BELOW THE BORING STAFF.

4 NOTES PERTAINING TO ALL BORINGS IN A SERIES OF BORINGS ARE SHOWN ON THE SHEET WITH THE FIRST BORING OF THAT SERIES.

DEFINITIONS OF TERMS USED ON THE BORING LOGS

THE TONGUE RIVER FORMATION IS AN "IMMATURE" ROCK THAT EXHIBITS BOTH ROCK AND SOIL CHARACTERISTICS. ROCK TERMS SUCH AS SANDSTONE, SILTSTONE AND SHALE ARE USED IN THE BORING LOGS RATHER THAN THE EQUIVALENT SOIL TERMS. THE CHOICE OF TERMS IS BASED ON PRECEDENCE ESTABLISHED IN THE LITERATURE AND OTHER CORPS OF ENGINEERS' PROJECTS.

BEDDING CHARACTERISTICS

HOMOGENEOUS - CONSTITUENT PARTICLES FORM A UNIFORM MASS WHICH IS CHARACTERIZED BY A LACK OF APPARENT BEDDING. MATERIAL IN WHICH STRATIFICATION WAS TOO SUBTLE TO BE APPARENT IN UNBROKEN CORE WAS CLASSIFIED HOMOGENEOUS.

LAMINATED - COMPONENT BEDS GENERALLY LESS THAN 3/8 INCH THICK. STRATA WERE CLASSIFIED AS LAMINATED ALTHOUGH MANY OF THE COMPONENT BEDS EXCEED THE LIMITING THICKNESS.

VERY THIN BEDDED - COMPONENT BEDS 3/8 TO 2 INCHES THICK

THIN BEDDED - COMPONENT BEDS 2 INCHES TO 2 FEET THICK

MEDIUM BEDDED - COMPONENT BEDS 2 TO 6 FEET THICK.

THICK BEDDED - COMPONENT BEDS 6 TO 8 FEET THICK.

MASSIVE - COMPONENT BEDS OVER 8 FEET THICK

HARDNESS AND DEGREE OF CEMENTATION

PLASTIC - CAN BE EASILY DEFORMED WITH FINGER

FRIABLE - CAN BE EASILY CRUMBLED WITH FINGERS

BRITTLE - CAN BE EASILY BROKEN WITHOUT PRODUCING PLASTIC DEFORMATION

VERY SOFT - CAN BE EASILY SCRATCHED WITH FINGER NAIL

SOFT - CAN BE SCRATCHED WITH FINGER NAIL

MODERATELY HARD - CAN BE EASILY SCRATCHED WITH KNIFE, CAN NOT BE SCRATCHED WITH FINGER NAIL

NONCEMENTED - NO CEMENTING AGENT BINDS GRAINS

POORLY CEMENTED - CAN BE CRUSHED OR BROKEN BY HAND WITH LITTLE DIFFICULTY

MODERATELY CEMENTED - CAN BE CRUSHED OR BROKEN BY HAND WITH DIFFICULTY

WELL CEMENTED - CANNOT BE BROKEN BY HAND

GENERAL NOTES

1 THE LEGEND REPRESENTS ONLY THE BASIC SOIL TYPES. DETAILED INFORMATION IS SHOWN AT THE RIGHT OF THE BORING LOG.

2 THE NATURAL WATER CONTENT IN PERCENT OF THE DRY WEIGHT IS SHOWN AT THE LEFT OF THE BORING STAFF.

3 ATTERBERG LIMITS LIQUID LIMIT (LL) AND PLASTIC LIMIT (PL), ARE SHOWN TO THE RIGHT OF THE BORING STAFF.

4 BLOW COUNT IS SHOWN TO THE EXTREME LEFT OF THE BORING STAFF. SEVERAL HAMMER WEIGHTS, SAMPLER SIZES AND LENGTHS OF HAMMER DROP ARE USED. BLOW COUNT IS, THEREFORE, EXPLAINED IN THE NOTES FOR EACH SERIES OF BORINGS.

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT CORPS OF ENGINEERS
ST PAUL, MINNESOTA

DESIGNED BY: R.W.
DRAWN BY:
TRACED BY: J.M.J.
CHECKED BY:
SUBMITTED BY:
APPROVED:

DESIGN MEMORANDUM NO 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

PRELIMINARY GEOLOGIC COLUMNS AND BORING LOG LEGEND

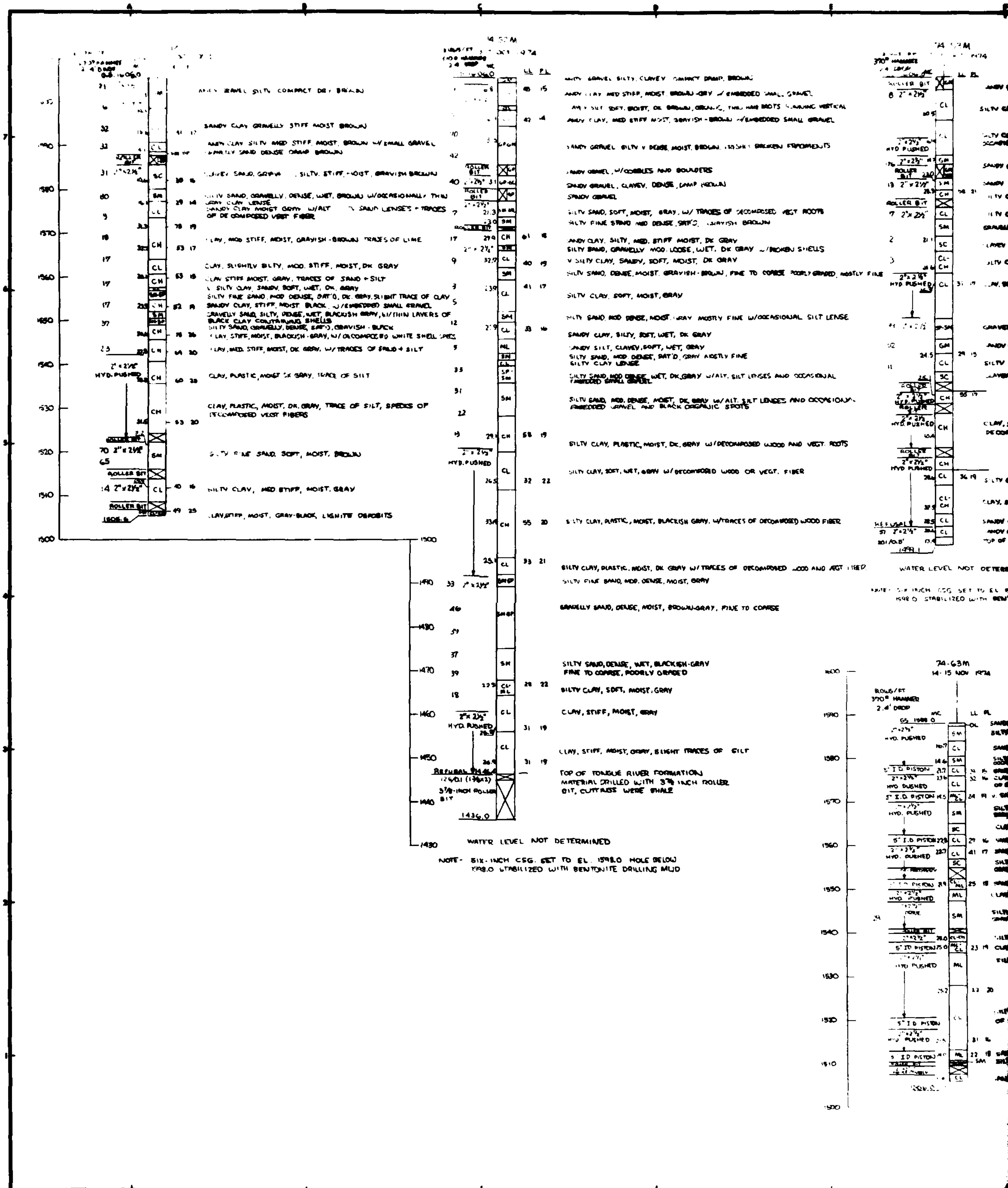
DATE: JUNE 1963

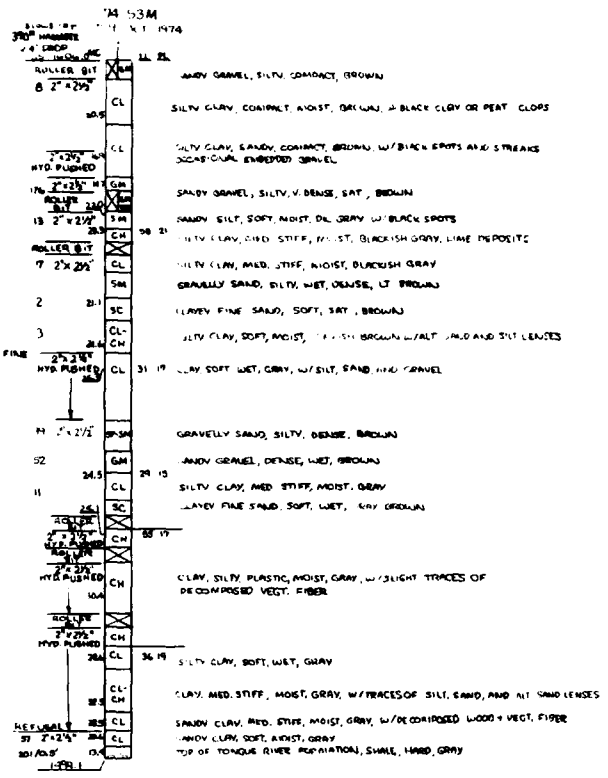
SCALE: AS SHOWN

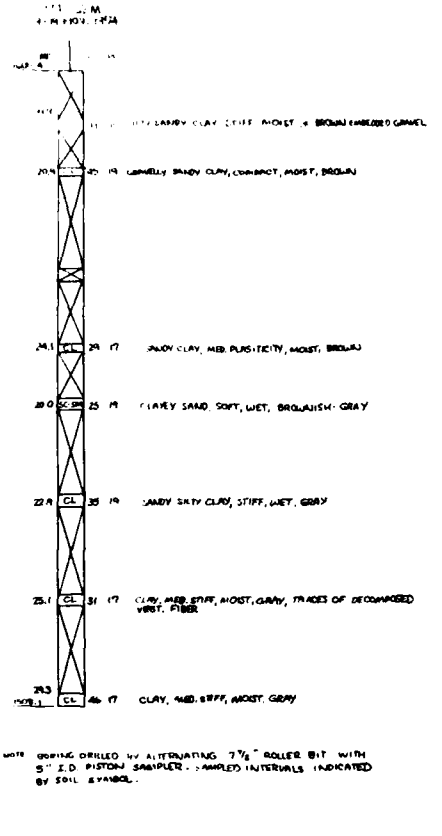
DRAWING NUMBER: RI-R-5/711

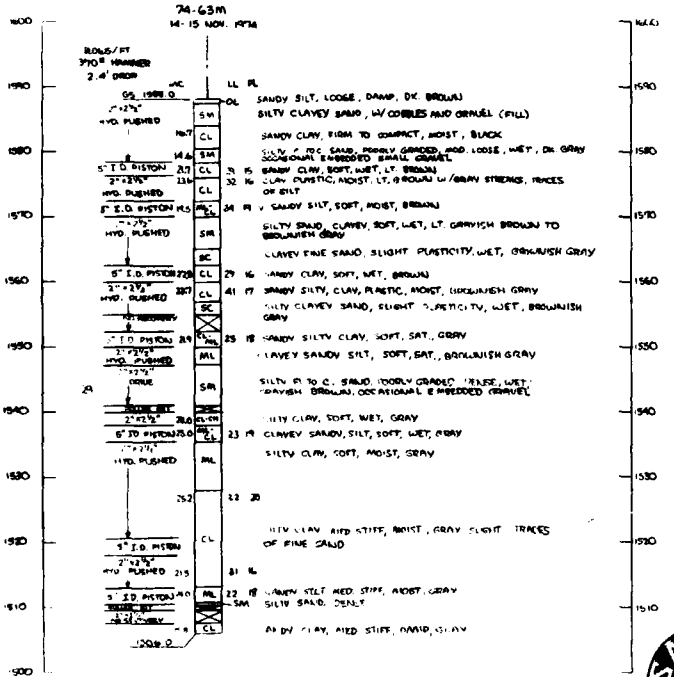
SHEET OF

PLATE NO B-12


74-63M
14-15 NOV 1974
BLOWS/FT
370# HAMMER
2.4' DROP
MC
LL PL
SANDY GRAVEL SILTY, CLAYEY, COMPACT, DAMP, BROWN
SANDY CLAY, MED STIFF, MOIST, BROWN-GRAY W/ EMBEDDED SMALL GRAVEL
SANDY CLAY, MED STIFF, MOIST, GRAYISH-BROWN W/EMBEDDED SMALL GRAVEL
SANDY GRAVEL, W/COBBLES AND BOULDERS
SANDY GRAVEL, CLAYEY, DENSE, DAMP, BROWN
SANDY GRAVEL
SILTY SAND, SOFT, MOIST, GRAY, W/ TRACES OF DECOMPOSED VEGT ROOTS
SILTY FINE SAND, MED DENSE, SAT'D, GRAYISH BROWN
SANDY CLAY, SILTY, MED. STIFF, MOIST, DK GRAY
SILTY SAND, GRAVELLY, MOD. LOOSE, WET, DK GRAY W/BROKEN SHELLS
SILTY CLAY, SOFT, MOIST, GRAY
SILTY SAND, MOD DENSE, MOIST, GRAY, MOSTLY FINE W/OCCASIONAL SILT LENSE
SANDY CLAY, SILTY, SOFT, WET, DK GRAY
SANDY SILT, CLAYEY, SOFT, WET, GRAY
SILTY SAND, MOD DENSE, SAT'D, GRAY MOSTLY FINE
SILTY CLAY LENSE
SILTY CLAY, PLASTIC, MOIST, DK GRAY W/DECOMPOSED WOOD AND VEGT ROOTS
SILTY CLAY, SOFT, WET, GRAY W/ DECOMPOSED WOOD OR VEGT. FIBER
SILTY CLAY, PLASTIC, MOIST, BLACKISH GRAY, W/TRACES OF DECOMPOSED WOOD FIBER
SILTY CLAY, PLASTIC, MOIST, DK GRAY W/ TRACES OF DECOMPOSED WOOD AND VEGT FIBER
SILTY FINE SAND, MOD. DENSE, MOIST, GRAY
GRAVELLY SAND, DENSE, MOIST, BROWN-GRAY, FINE TO COARSE
SILTY SAND, DENSE, WET, BLACKISH-GRAY
FINE TO COARSE, POORLY GRADED
SILTY CLAY, SOFT, MOIST, GRAY
CLAY, STIFF, MOIST, GRAY
CLAY, STIFF, MOIST, GRAY, SLIGHT TRACES OF SILT
TOP OF TONGUE RIVER FORMATION
MATERIAL DRILLED WITH 3⅞ INCH ROLLER BIT, CUTTINGS WERE SHALE
WATER LEVEL NOT DETERMINED
NOTE- SIX-INCH CSG. SET TO EL. 1598.0 HOLE BELOW 1598.0 STABILIZED WITH BENTONITE DRILLING MUD
HYD. PUSHED
ROLLER BIT
REFUSAL
5" I.D. PISTON
CLAY, PLASTIC, MOIST, DK GRAY, TRACE OF SILT
CLAY, PLASTIC, MOIST, DK GRAY, TRACE OF SILT, SPECKS OF DECOMPOSED VEGT FIBERS
SILTY FINE SAND, SOFT, MOIST, BROWN
SILTY CLAY, MED STIFF, MOIST, GRAY
CLAY, STIFF, MOIST, GRAY-BLACK, LIGNITE DEPOSITS
CLAY, SLIGHTLY SILTY, MOD. STIFF, MOIST, DK GRAY
1600
1590
1580
1570
1560
1550
1540
1530
1520
1510
1500
1490
1480
1470
1460
1450
1440
1430
A
B
C
D
E







SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
ST PAUL, MINNESOTA

DESIGNED BY: L H B
DRAWN BY: L H B
TRACED BY: M M B
SUBMITTED BY:

DESIGN MEMORANDUM NO 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
LAKE DARLING DAM
74-51M THRU 74-53M, 74-62M AND 74-63M

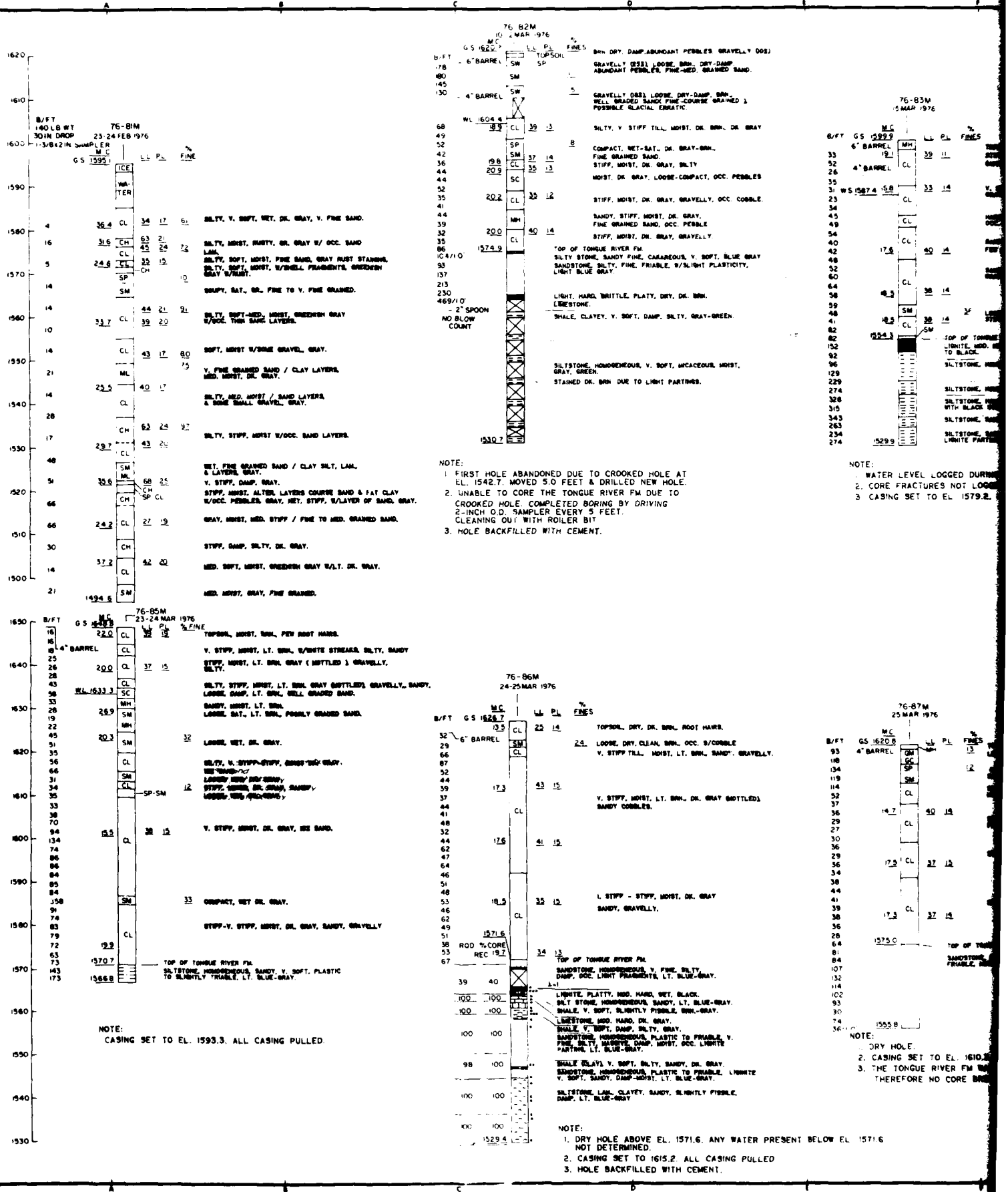
APPROVED: DATE: JUNE 1983

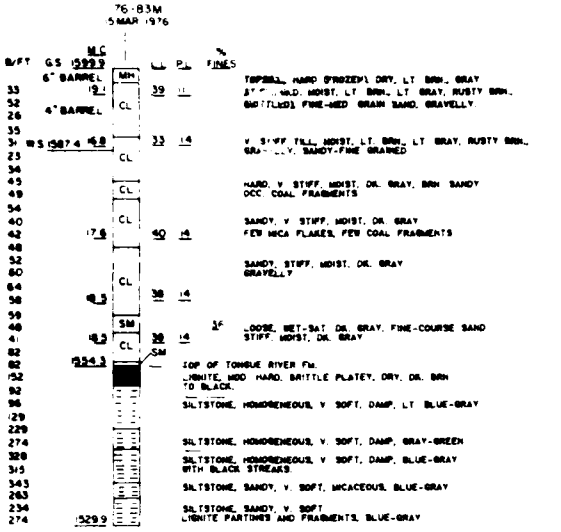
SCALE: DRG. NO.

DRAWING NUMBER
RI-R-5/707

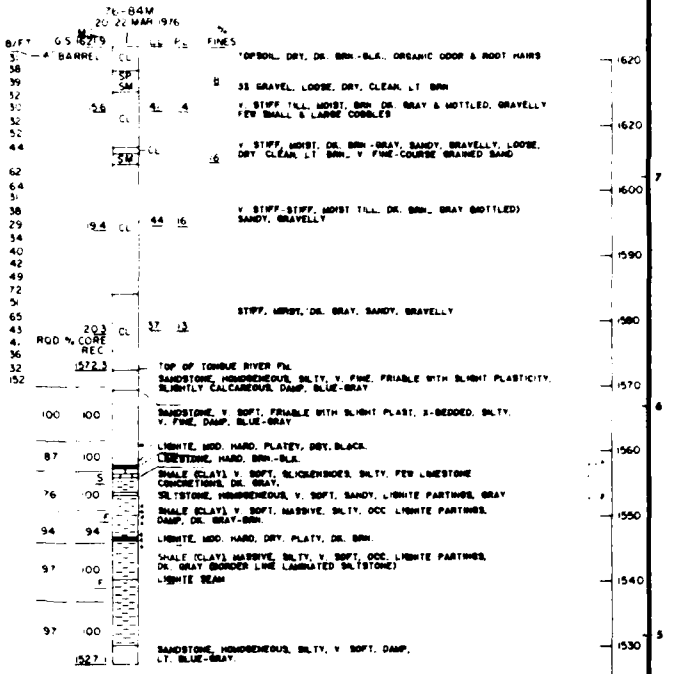
SHEET OF

PLATE NO. B-13


76-81M
23-24 FEB 1976
B/FT
140 LB WT
30 IN DROP
1-3/8 x 2 IN SAMPLER
M C
G S 1595.1
LL PL
% FINE
ICE
WATER
SILTY, V. SOFT, WET, DK. GRAY, V. FINE SAND.
SILTY, MOIST, PARTLY, GR. GRAY W/ OCC. SAND LAM.
SILTY, SOFT, MOIST, FINE SAND, GRAY RUST STAINS.
SILTY, SOFT, MOIST, W/SHELL FRAGMENTS, GREENISH GRAY W/RUST.
SANDY, SAT., GR., FINE TO V. FINE GRAINED.
SILTY, SOFT-MED., MOIST, GREENISH GRAY W/OCC. THIN SAND LAYERS.
SOFT, MOIST W/SOME GRAVEL, GRAY.
V. FINE GRAINED SAND / CLAY LAYERS, MED. MOIST, DK. GRAY.
SILTY, MED. MOIST / SAND LAYERS, & SOME SMALL GRAVEL, GRAY.
SILTY, STIFF, MOIST W/OCC. SAND LAYERS.
WET, FINE GRAINED SAND / CLAY SILT, LAM. & LAYERS, GRAY.
V. STIFF, DAMP, GRAY.
STIFF, MOIST, ALTER. LAYERS COURSE SAND & FAT CLAY W/OCC. PEBBLES, GRAY, WET, STIFF, W/LAYER OF SAND, GRAY.
GRAY, MOIST, MED. STIFF / FINE TO MED. GRAINED SAND.
STIFF, DAMP, SILTY, DK. GRAY.
MED. SOFT, MOIST, GREENISH GRAY W/LT. DK. GRAY.
MED. MOIST, GRAY, FINE GRAINED.
1494.6
76-82M
10-2 MAR 1976
G S 1629.7
TOPSOIL
6" BARREL
4" BARREL
WL 1604.4
2" SPOON NO BLOW COUNT
BRN DRY, DAMP, ABUNDANT PEBBLES, GRAVELLY (OS)
GRAVELLY (OS)1, LOOSE, BRN., DRY-DAMP, ABUNDANT PEBBLES, FINE-MED. GRAINED SAND.
GRAVELLY (OS)1, LOOSE, DRY-DAMP, BRN., WELL GRADED SAND(FINE-COURSE GRAINED), POSSIBLE GLACIAL ERRATIC.
SILTY, V. STIFF TILL, MOIST, DK. BRN., DK. GRAY
COMPACT, WET-SAT., DK. GRAY-GRN., FINE GRAINED SAND.
STIFF, MOIST, DK. GRAY, SILTY
MOIST, DK. GRAY, LOOSE-COMPACT, OCC. PEBBLES
STIFF, MOIST, DK. GRAY, GRAVELLY, OCC. COBBLE.
SANDY, STIFF, MOIST, DK. GRAY, FINE GRAINED SAND, OCC. PEBBLE
STIFF, MOIST, DK. GRAY, GRAVELLY.
1574.9
TOP OF TONGUE RIVER FM.
SILTY STONE, SANDY FINE, CARAREOUS, V. SOFT, BLUE GRAY
SANDSTONE, SILTY, FINE, FRIABLE, W/SLIGHT PLASTICITY, LIGHT BLUE GRAY.
LIGHT, HARD, BRITTLE, PLATY, DRY, DK. BRN. LIMESTONE.
SHALE, CLAYEY, V. SOFT, DAMP, SILTY, GRAY-GREEN
SILTSTONE, HOMOGENEOUS, V. SOFT, MICACEOUS, MOIST, GRAY, GREEN.
STAINED DK. BRN DUE TO LIGHT PARTINGS.
1530.7
NOTE:
1. FIRST HOLE ABANDONED DUE TO CROOKED HOLE AT EL. 1542.7. MOVED 5.0 FEET & DRILLED NEW HOLE.
2. UNABLE TO CORE THE TONGUE RIVER FM DUE TO CROOKED HOLE. COMPLETED BORING BY DRIVING 2-INCH O.D. SAMPLER EVERY 5 FEET. CLEANING OUT WITH ROILER BIT
3. HOLE BACKFILLED WITH CEMENT.
76-83M
15 MAR 1976
G S 1599.9
6" BARREL
4" BARREL
WS 1587.4
1554.3
1529.9
NOTE:
1. WATER LEVEL LOGGED DURIN
2. CORE FRACTURES NOT LOGG
3. CASING SET TO EL. 1579.2.
76-85M
23-24 MAR 1976
G S 1648.8
4" BARREL
WL 1633.3
TOPSOIL, MOIST, BRN., FEW ROOT HAIRS.
V. STIFF, MOIST, LT. BRN., W/WHITE STREAKS, SILTY, SANDY
STIFF, MOIST, LT. BRN. GRAY (MOTTLED), GRAVELLY, SILTY.
SILTY, STIFF, MOIST, LT. BRN. GRAY (MOTTLED), GRAVELLY, SANDY.
LOOSE, DAMP, LT. BRN., WELL GRADED SAND.
SANDY, MOIST, LT. BRN.
LOOSE, SAT., LT. BRN., POORLY GRADED SAND.
LOOSE, WET, DK. GRAY.
SILTY, V. STIFF-STIFF, MOIST, DK. GRAY.
LOOSE, MOIST, DK. GRAY,
STIFF, MOIST, DK. GRAY, SANDY,
LOOSE, WET, GRAY, SANDY,
V. STIFF, MOIST, DK. GRAY, SOME SAND.
COMPACT, WET DK. GRAY.
STIFF-V. STIFF, MOIST, DK. GRAY, SANDY, GRAVELLY
1570.7
TOP OF TONGUE RIVER FM.
SILTSTONE, HOMOGENEOUS, SANDY, V. SOFT, PLASTIC TO SLIGHTLY FRIABLE, LT. BLUE-GRAY.
1566.8
NOTE:
CASING SET TO EL. 1593.3. ALL CASING PULLED.
76-86M
24-25 MAR 1976
G S 1626.7
6" BARREL
ROD % CORE REC 19.7
1571.6
TOPSOIL, DRY, DK. BRN., ROOT HAIRS.
LOOSE, DRY, CLEAN, BRN., OCC. S/COBBLE
V. STIFF TILL, MOIST, LT. BRN., SAND*, GRAVELLY.
V. STIFF, MOIST, LT. BRN., DK. GRAY (MOTTLED), SANDY COBBLES.
I. STIFF - STIFF, MOIST, DK. GRAY SANDY, GRAVELLY.
TOP OF TONGUE RIVER FM.
SANDSTONE, HOMOGENEOUS, V. FINE, SILTY, DAMP, OCC. LIGHT FRAGMENTS, LT. BLUE-GRAY.
LIGNITE, PLATTY, MOD. HARD, WET, BLACK.
SILT STONE, HOMOGENEOUS, SANDY, LT. BLUE-GRAY.
SHALE, V. SOFT, SLIGHTLY FISSILE, BRN.-GRAY.
LIMESTONE, MOD. HARD, DK. GRAY.
SHALE, V. SOFT, DAMP, SILTY, GRAY.
SANDSTONE, HOMOGENEOUS, PLASTIC TO FRIABLE, V. FINE, SILTY, MASSIVE, DAMP, MOIST, OCC. LIGNITE PARTING, LT. BLUE-GRAY.
SHALE (CLAY), V. SOFT, SILTY, SANDY, DK. GRAY.
SANDSTONE, HOMOGENEOUS, PLASTIC TO FRIABLE, LIGNITE V. SOFT, SANDY, DAMP-MOIST, LT. BLUE-GRAY.
SILTSTONE, LAM., CLAYEY, SANDY, SLIGHTLY FISSILE, DAMP, LT. BLUE-GRAY
1529.4
NOTE:
1. DRY HOLE ABOVE EL. 1571.6. ANY WATER PRESENT BELOW EL. 1571.6 NOT DETERMINED.
2. CASING SET TO 1615.2 ALL CASING PULLED
3. HOLE BACKFILLED WITH CEMENT.
76-87M
25 MAR 1976
G S 1620.8
4" BARREL
1575.0
1555.8
NOTE:
1. DRY HOLE.
2. CASING SET TO EL. 1610.
3. THE TONGUE RIVER FM
THEREFORE NO CORE



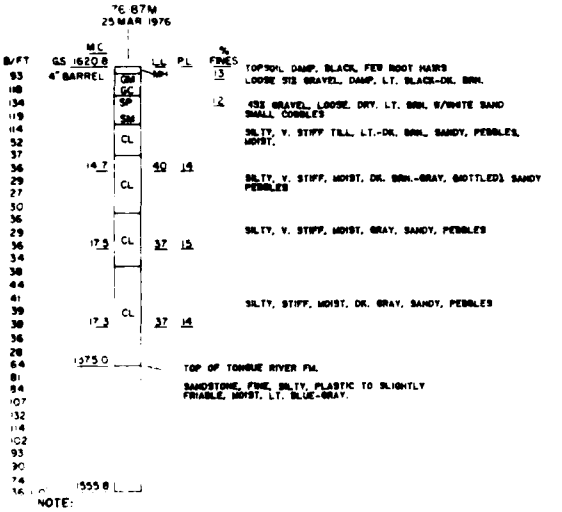
NOTE:
1. WATER LEVEL LOGGED DURING DRILLED AS A WATER ENCOUNTER
2. CORE FRACTURES NOT LOGGED.
3. CASING SET TO EL. 1579.2. ALL CASINGS PULLED.



NOTE:
1. WATER LEVEL NOT DETERMINED.
2. HOLE BACKFILLED WITH CEMENT.
3. CASING SET TO EL. 1606.3. ALL CASING PULLED.

NOTES FOR BORINGS 76-81M THROUGH 76-111M

1. PENETRATION RESISTANCE IS SHOWN TO THE LEFT AT THE BORING STAFF UNLESS OTHERWISE INDICATED, THE NUMBERS REPRESENT THE BLOWS NECESSARY TO ADVANCE A 4 OR 6-INCH I.D. DRIVE BARREL 2 FT WITH A 470-LB. DRILL STEM FALLING 24 INCHES.
2. UNLESS OTHERWISE INDICATED, THE WATER LEVEL SHOWN REPRESENTS THE LEVEL AT WHICH FREE WATER WAS FIRST APPARENT IN THE SAMPLES. ACTUAL WATER DETERMINATIONS WERE NOT MADE.
3. UNLESS OTHERWISE INDICATED, THE CASINGS USED WAS 5-1/2 INCHES I.D.
4. UNLESS OTHERWISE INDICATED, THE HOLES WERE BACKFILLED WITH SOIL COMPACTED DURING BACKFILLING WITH A 470-LB. DRILL STEM.
5. THE VERTICAL SCALE FOR BORINGS 76-107M THROUGH 76-111M IS DEPTH BELOW GROUND SURFACE.



NOTE:
1. DRY HOLE.
2. CASING SET TO EL. 1610.3. ALL CASINGS PULLED
3. THE TONGUE RIVER FM WAS DRIVE SAMPLED: THEREFORE NO CORE BREAKS OR FRACTURES WERE LOGGED

WATER PRESENT BELOW EL 1571.6
PULLED

DIVISION	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT CORPS OF ENGINEERS
ST PAUL, MINNESOTA

TRACING BY	L H B
DRAWN BY	J M J
CHECKED BY	M M B
SUBMITTED BY	
APPROVED	

DESIGN MEMORANDUM NO 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

LAKE DARLING DAM

76-81M THRU 76-87M

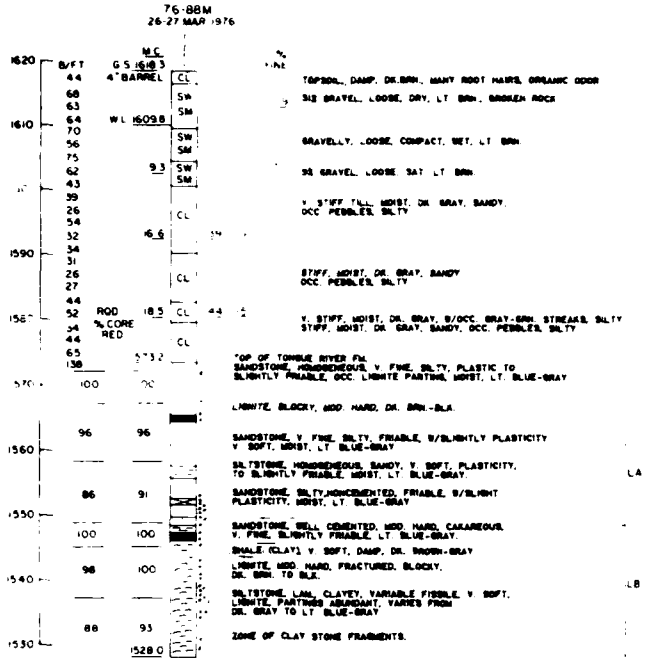
DATE
JUNE 1983

DRAWING NUMBER
RI-R-5/713

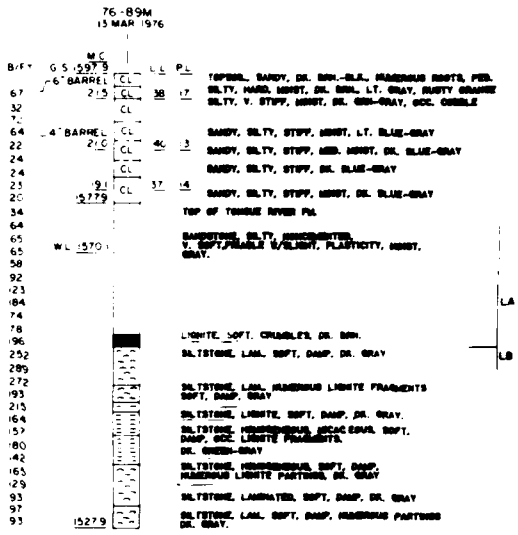
SHEET OF

SAFETY DAYS

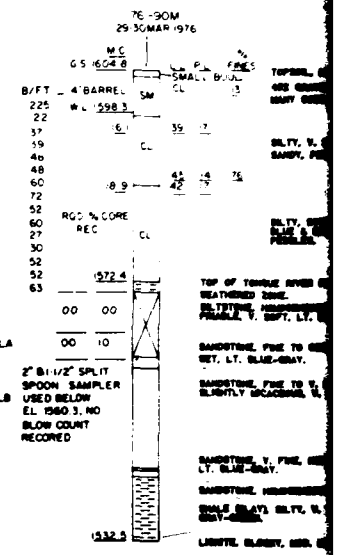
PLATE NO B-14



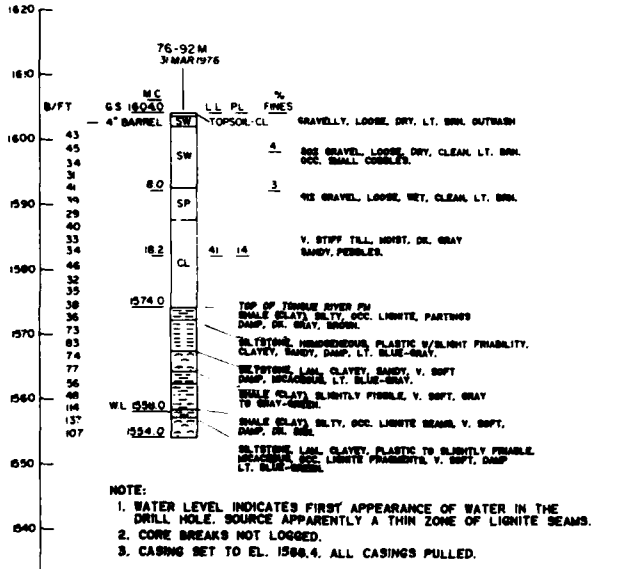
NOTE:
1. APPROXIMATELY 400 GAL. WATER LOSS, IN LIGNITE BED AT EL. 1547.1
2. CASING SET TO EL. 1639.0. ALL CASINGS PULLED.
3. HOLE BACKFILLED WITH CEMENT.



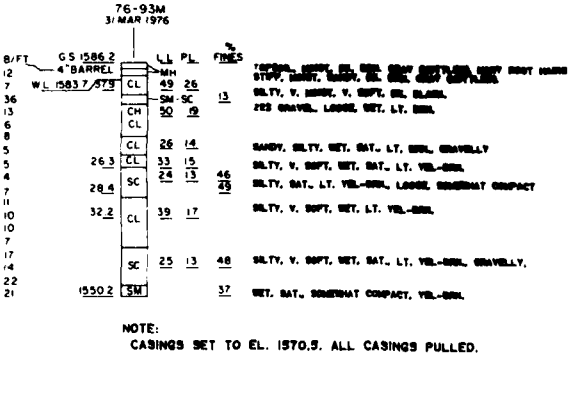
NOTE:
1. NO CASINGS USED IN HOLE
2. TONGUE RIVER FM. DRIVE SAMPLED, THEREFORE NO CORE BREAKS OR FRACTURES WERE LOGGED.



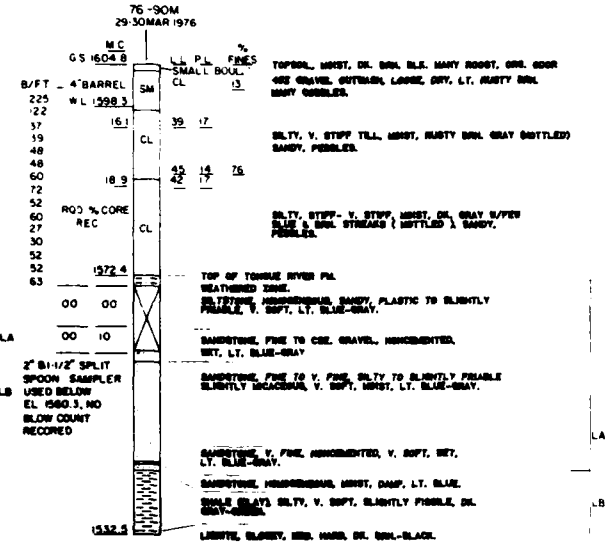
NOTE:
1. CASINGS SET TO EL. 1598.3. ALL
2. LOST CORE DUE TO CROOKED H
3. HOLE BACKFILLED W/CEMENT.



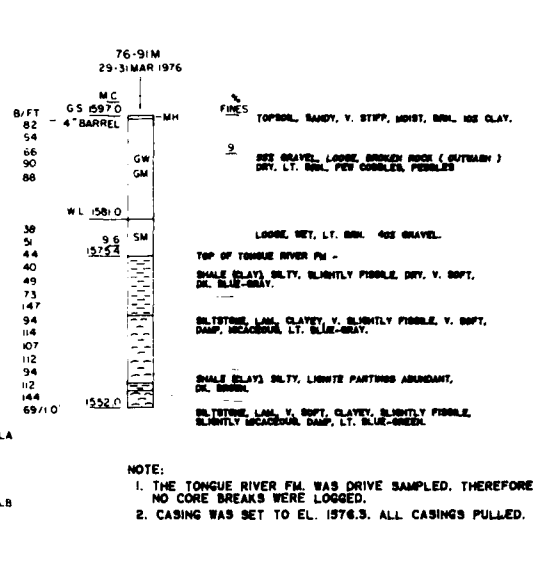
NOTE:
1. WATER LEVEL INDICATES FIRST APPEARANCE OF WATER IN THE DRILL HOLE. SOURCE APPARENTLY A THIN ZONE OF LIGNITE SEAMS.
2. CORE BREAKS NOT LOGGED.
3. CASING SET TO EL. 1568.4. ALL CASINGS PULLED.



NOTE:
CASINGS SET TO EL. 1570.9. ALL CASINGS PULLED.



NOTE:
1. CASINGS SET TO EL. 1598.3. ALL CASINGS PULLED.
2. LOST CORE DUE TO CROOKED HOLE & GRAVEL.
3. HOLE BACKFILLED W/CEMENT.



NOTE:
1. THE TONGUE RIVER FM. WAS DRIVE SAMPLED. THEREFORE NO CORE BREAKS WERE LOGGED.
2. CASING WAS SET TO EL. 1576.3. ALL CASINGS PULLED.

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

DESIGN MEMORANDUM NO 3 GENERAL

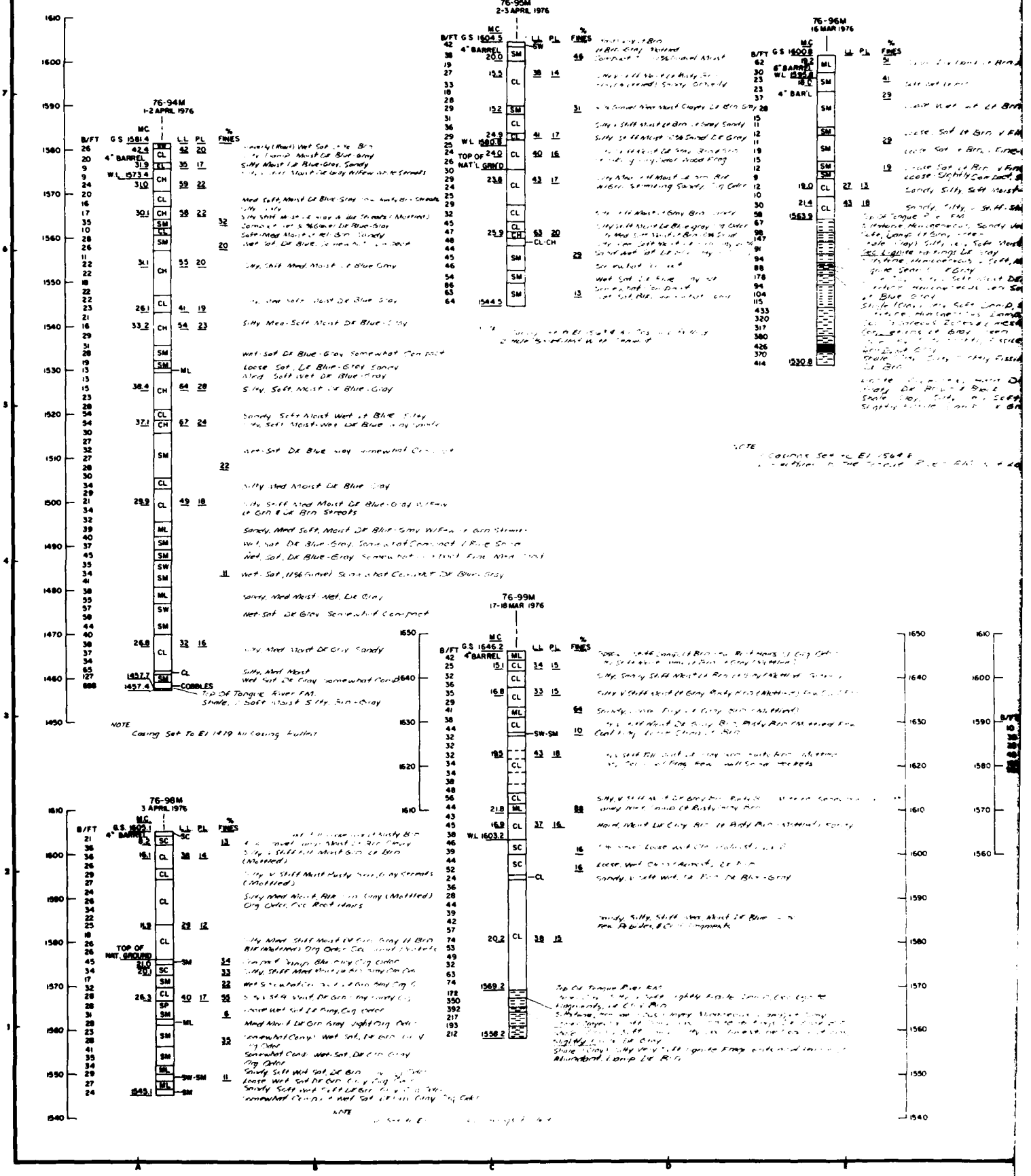
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
LAKE DARLING DAM
76-88M THRU 76-93M

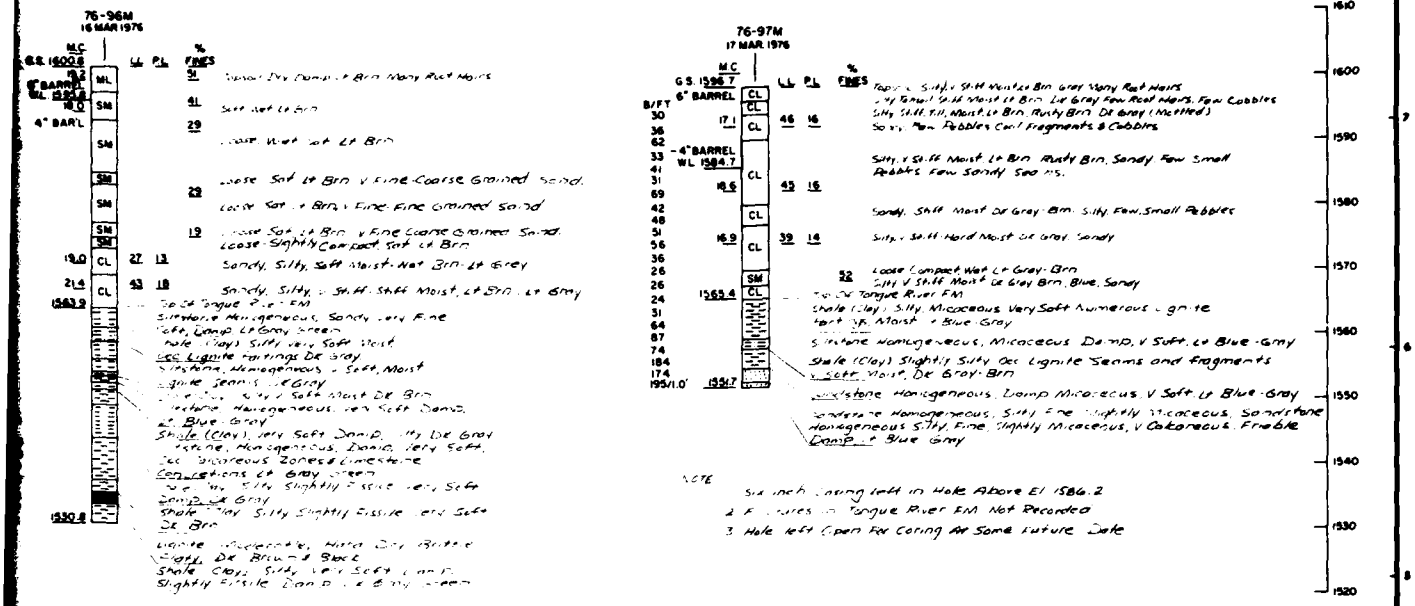
DESIGNED BY: LHB
DRAWN BY: J.M.J
CHECKED BY: MMB
SUBMITTED BY:
APPROVED:
DATE: JUNE 1983

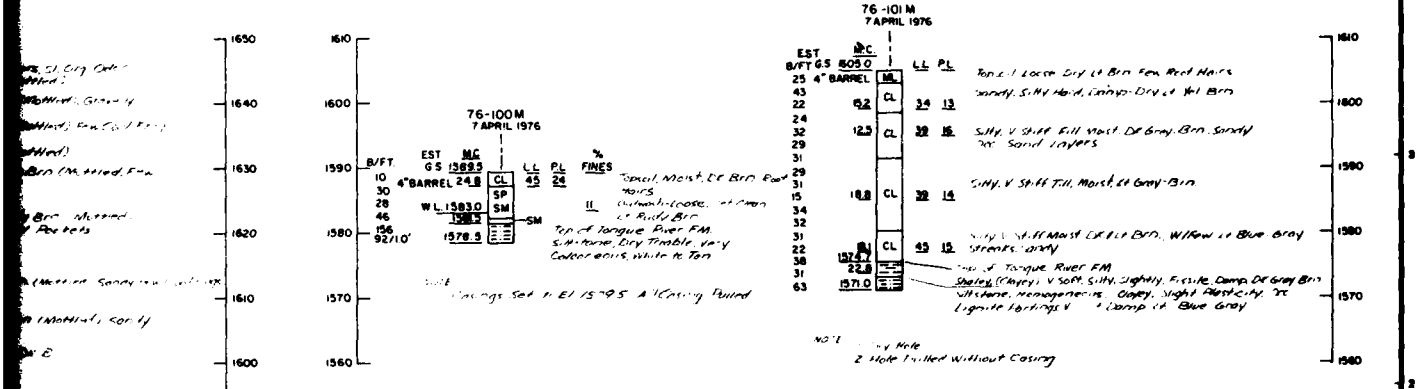
DRAWING NUMBER
R1-R-5/714
SHEET OF

SAFETY PAYS

PLATE NO B-15


76-94M
1-2 APRIL 1976
76-95M
2-3 APRIL 1976
76-96M
16 MAR 1976
76-98M
3 APRIL 1976
76-99M
17-18 MAR 1976
NOTE
Casing Set To El 1419 in Casing Bullet
NOTE





DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
ST PAUL, MINNESOTA

DESIGN MEMORANDUM NO 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

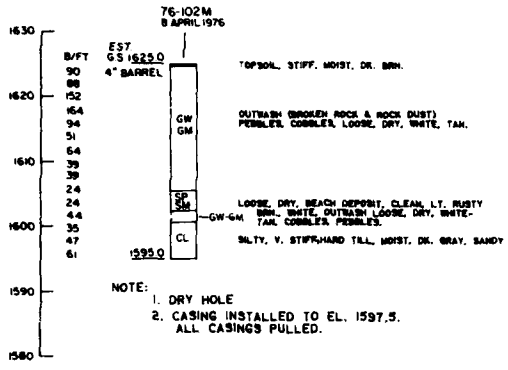
LAKE DARLING DAM
76-94M THRU 76-101M

DESIGNED BY: L.H.B
DRAWN BY: J.M.J
TRACED BY: M.M.B
SUBMITTED BY:
APPROVED:
DATE: JUNE 1983

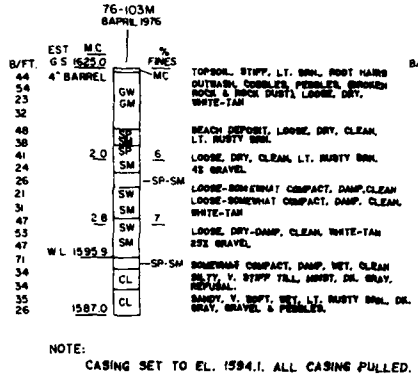
DRAWING NUMBER
RI-R-5/715
SHEET OF

SAFETY PAYS

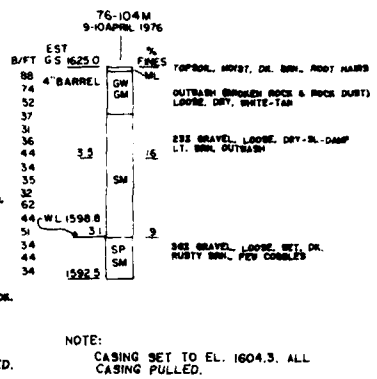
PLATE NO. B-16



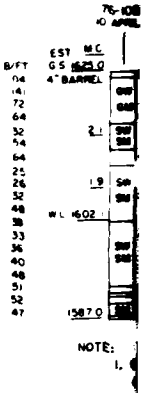
NOTE:
1. DRY HOLE
2. CASING INSTALLED TO EL. 1597.5. ALL CASINGS PULLED.



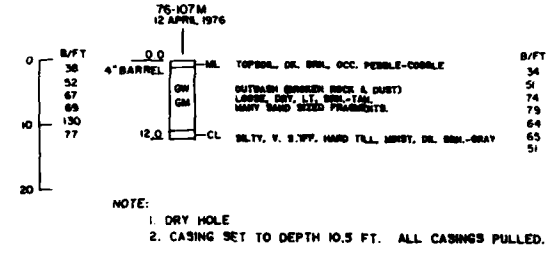
NOTE:
CASING SET TO EL. 1594.1. ALL CASING PULLED.



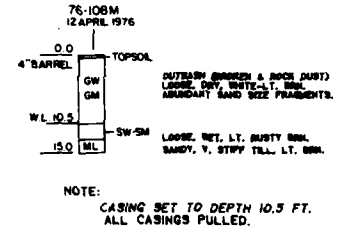
NOTE:
CASING SET TO EL. 1604.3. ALL CASING PULLED.



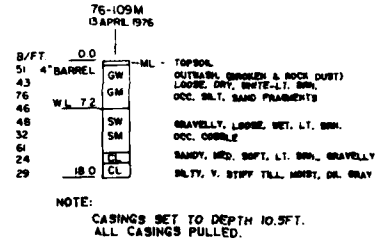
NOTE:
1.



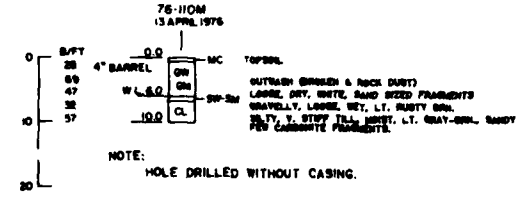
NOTE:
1. DRY HOLE
2. CASING SET TO DEPTH 10.5 FT. ALL CASINGS PULLED.



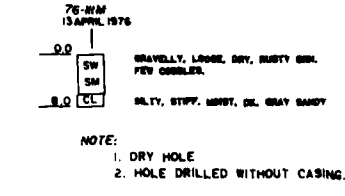
NOTE:
CASING SET TO DEPTH 10.5 FT. ALL CASINGS PULLED.



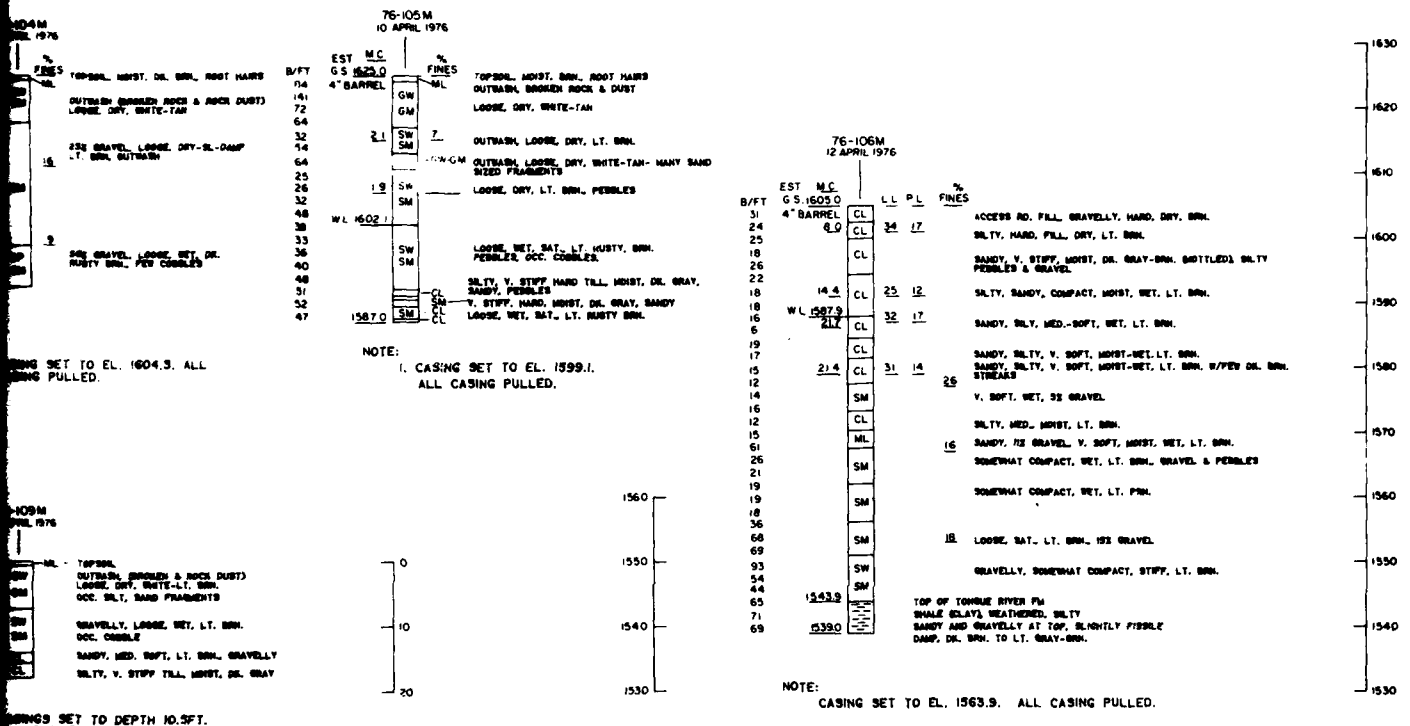
NOTE:
CASINGS SET TO DEPTH 10.5FT. ALL CASINGS PULLED.



NOTE:
HOLE DRILLED WITHOUT CASING.



NOTE:
1. DRY HOLE
2. HOLE DRILLED WITHOUT CASING.



...04M
...1976
% FINES
TOPSOIL, MOIST, DK. BRN., ROOT HAIRS
OUTWASH BROKEN ROCK & ROCK DUST) LOOSE, DRY, WHITE-TAN
25% GRAVEL, LOOSE, DRY-SL.-DAMP LT. BRN., OUTWASH
16
9
24% GRAVEL, LOOSE, WET, DK. RUSTY BRN., FEW COBBLES
...NG SET TO EL. 1604.3. ALL ...NG PULLED.

...09M
...1976
ML - TOPSOIL
OUTWASH, (BROKEN & ROCK DUST) LOOSE, DRY, WHITE-LT. BRN. OCC. SILT, SAND FRAGMENTS
GRAVELLY, LOOSE, WET, LT. BRN. OCC. COBBLE
SANDY, MED. SOFT, LT. BRN., GRAVELLY
SILTY, V. STIFF TILL, MOIST, DK. GRAY
0
10
20
1560
1550
1540
1530
...NGS SET TO DEPTH 10.5FT.
...L CASINGS PULLED.

SYMBOL	DESCRIPTION	DATE	APPROVAL

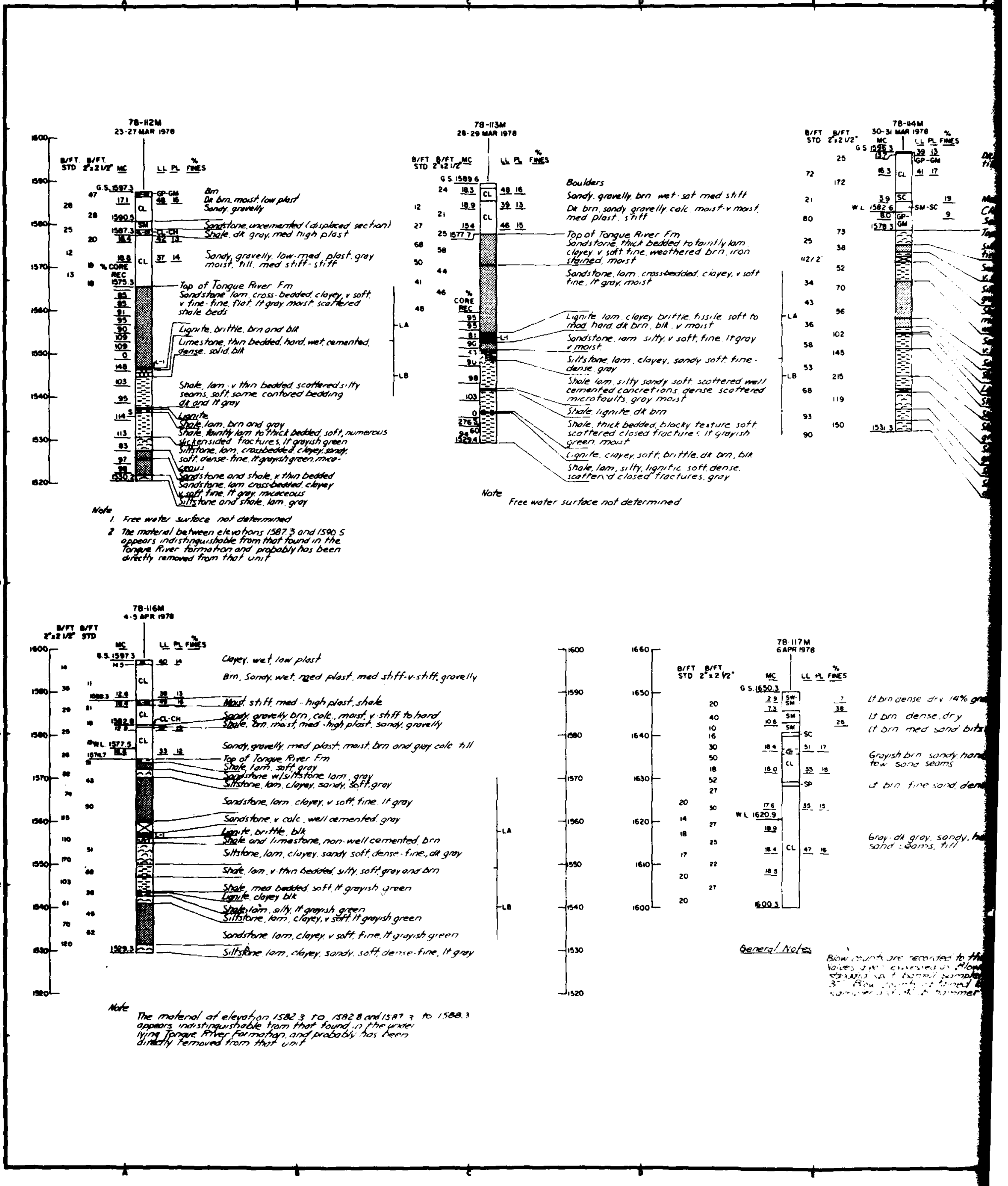
DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
ST PAUL, MINNESOTA

DESIGNED BY: L H B	DESIGN MEMORANDUM NO 3 GENERAL
DRAWN BY: J.M.J.	FLOOD CONTROL - LAKE DARLING SOURIS RIVER, NORTH DAKOTA
TRACED BY: M M B	LAKE DARLING DAM
SUBMITTED BY:	76-102M THRU 76-111M
APPROVED:	DATE: JUNE 1983
	SCALE / SPEC. NO.
	DRAWING NUMBER RI-R-5/716
	SHEET OF

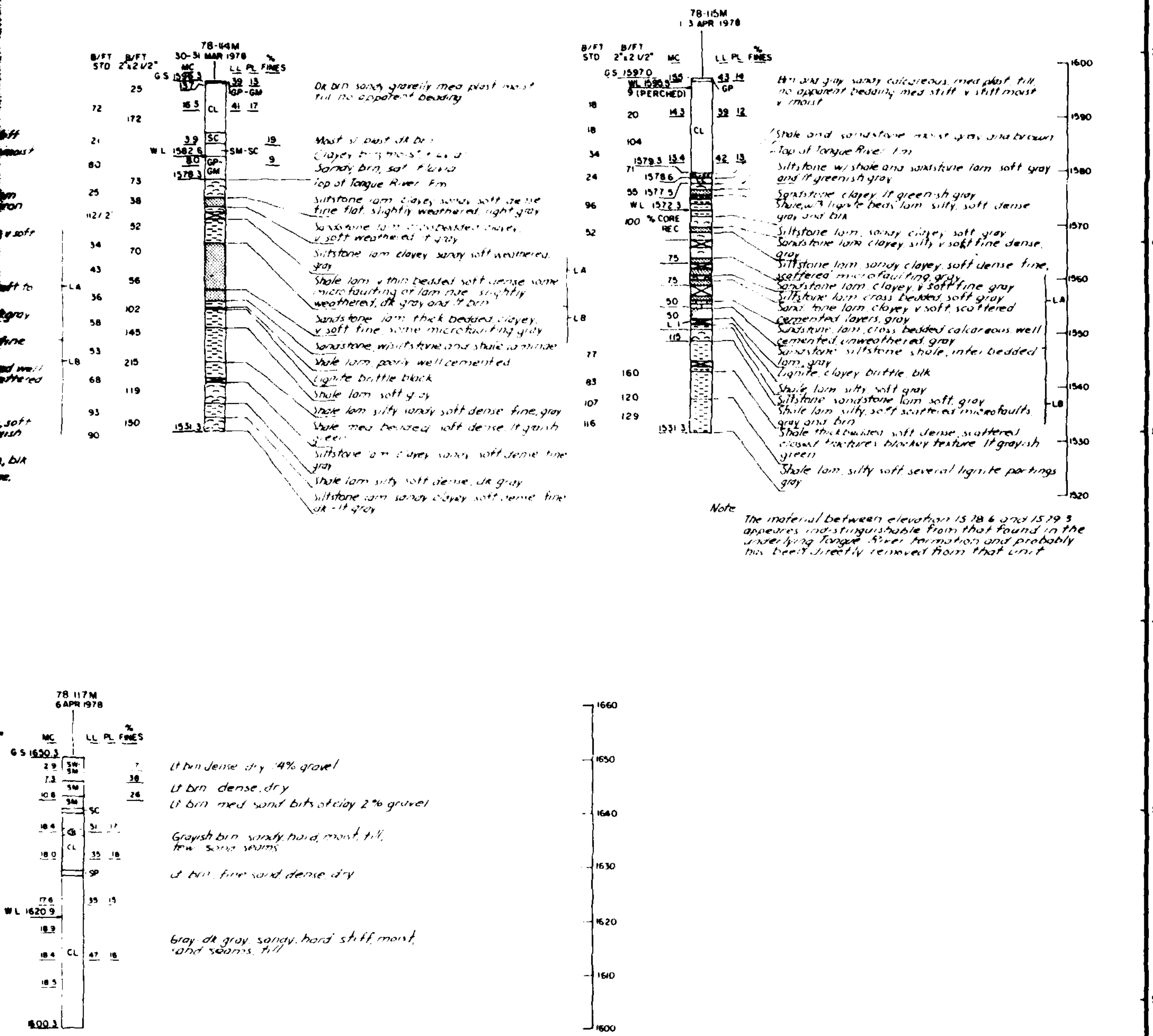
SAFETY PAYS

PLATE NO B-17

1 2



78-112M
23-27 MAR 1978
B/FT STD
B/FT 2"x2 1/2"
MC
LL PL % FINES
G.S. 1597.3
GP-GM
CL
SM
CL-CH
% CORE REC
Brn
Dk brn, moist, low plast
Sandy, gravelly
Sandstone, uncemented (displaced section)
Shale, dk gray, med high plast
Sandy, gravelly, low-med plast, gray moist, till, med stiff-stiff
Top of Tongue River Fm
Sandstone, lam, cross-bedded, clayey, v soft, v fine-fine, flat, lt gray, moist, scattered shale beds
Lignite, brittle, brn and blk
Limestone, thin bedded, hard, wet, cemented, dense, solid, blk
Shale, lam - v thin bedded, scattered silty seams, soft, some contored bedding, dk and lt gray
Lignite
Shale, lam, brn and gray
Shale, faintly lam to thick bedded, soft, numerous slickensided fractures, lt grayish green
Siltstone, lam, crossbedded, clayey, sandy, soft, dense-fine, lt grayish green, micaceous
Sandstone and shale, v thin bedded
Sandstone, lam, cross-bedded, clayey, v soft, fine, lt gray, micaceous
Siltstone and shale, lam, gray
LA
LB
L-1
Note
1. Free water surface not determined
2. The material between elevations 1587.3 and 1590.5 appears indistinguishable from that found in the Tongue River formation and probably has been directly removed from that unit
78-113M
28-29 MAR 1978
G.S. 1589.6
Boulders
Sandy, gravelly, brn, wet-sat, med stiff
Dk brn, sandy, gravelly, calc, moist-v moist, med plast, stiff
Top of Tongue River Fm
Sandstone, thick bedded to faintly lam, clayey, v soft, fine, weathered brn, iron stained, moist
Sandstone, lam, crossbedded, clayey, v soft, fine, lt gray, moist
Lignite, lam, clayey, brittle, fissile, soft to mod hard, dk brn, blk, v moist
Sandstone, lam, silty, v soft, fine, lt gray, v moist
Siltstone, lam, clayey, sandy, soft, fine-dense, gray
Shale, lam, silty, sandy, soft, scattered well cemented concretions, dense, scattered microfaults, gray, moist
Shale, lignite, dk brn
Shale, thick bedded, blocky texture, soft, scattered closed fractures, lt grayish green, moist
Lignite, clayey, soft, brittle, dk brn, blk
Shale, lam, silty, lignitic, soft, dense, scattered closed fractures, gray
Note
Free water surface not determined
78-114M
30-31 MAR 1978
W.L. 1582.6
SM-SC
GP-GM
78-116M
4-5 APR 1978
G.S. 1597.3
W.L. 1577.5
Clayey, wet, low plast
Brn, sandy, wet, med plast, med stiff-v stiff, gravelly
Moist, stiff, med-high plast, shale
Sandy, gravelly, brn, calc, moist, v stiff to hard
Shale, lam, moist, med-high plast, sandy, gravelly
Sandy, gravelly, med plast, moist, brn and gray, calc, till
Top of Tongue River Fm
Shale, lam, soft, gray
Sandstone w/siltstone, lam, gray
Siltstone, lam, clayey, sandy, soft, gray
Sandstone, lam, clayey, v soft, fine, lt gray
Sandstone, v calc, well cemented, gray
Lignite, brittle, blk
Shale and limestone, non-well cemented, brn
Siltstone, lam, clayey, sandy, soft, dense-fine, dk gray
Shale, lam, v thin bedded, silty, soft, gray and brn
Shale, med bedded, soft, lt grayish green
Lignite, clayey, blk
Shale, lam, silty, lt grayish green
Siltstone, lam, clayey, v soft, lt grayish green
Sandstone, lam, clayey, v soft, fine, lt grayish green
Siltstone, lam, clayey, sandy, soft, dense-fine, lt gray
Note
The material at elevation 1582.3 to 1582.8 and 1587.3 to 1588.3 appears indistinguishable from that found in the underlying Tongue River Formation, and probably has been directly removed from that unit
78-117M
6 APR 1978
G.S. 1650.3
W.L. 1620.9
SW-SM
SM
SC
CL
SP
Lt brn, dense, dry
Lt brn, med sand
Grayish brn, sandy, few sand seams
Lt brn, fine sand
Gray-dk gray, sandy, sand seams, till
General Notes



General Notes

Blow counts are recorded to the extreme left of each boring. Stiff values were obtained with a 2" x 2 1/2" standard split barrell sampler driven by a 140 lb hammer falling 30". Blow counts obtained by use of a 2" x 2 1/2" barrell sampler and 140 lb hammer are as given.

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
ST PAUL, MINNESOTA

DESIGN MEMORANDUM NO 5 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

LAKE DARLING DAM

78-112M THRU 78-117M

DESIGNED BY: L H B
DRAWN BY: J M J
CHECKED BY: M M B
SUBMITTED BY
APPROVED:

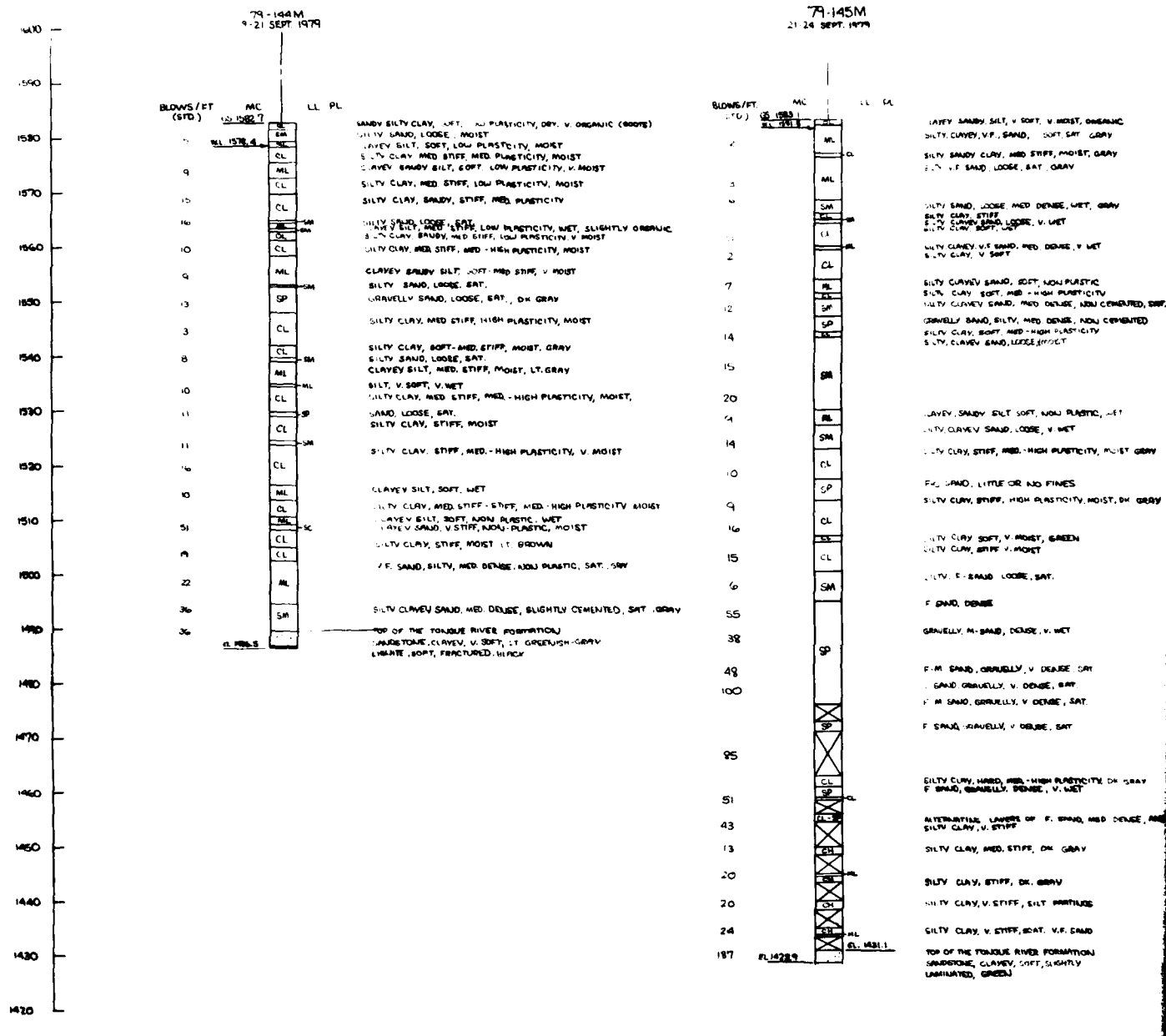
DATE: JUNE 1983

DRAWING NUMBER
RI-R-5/717

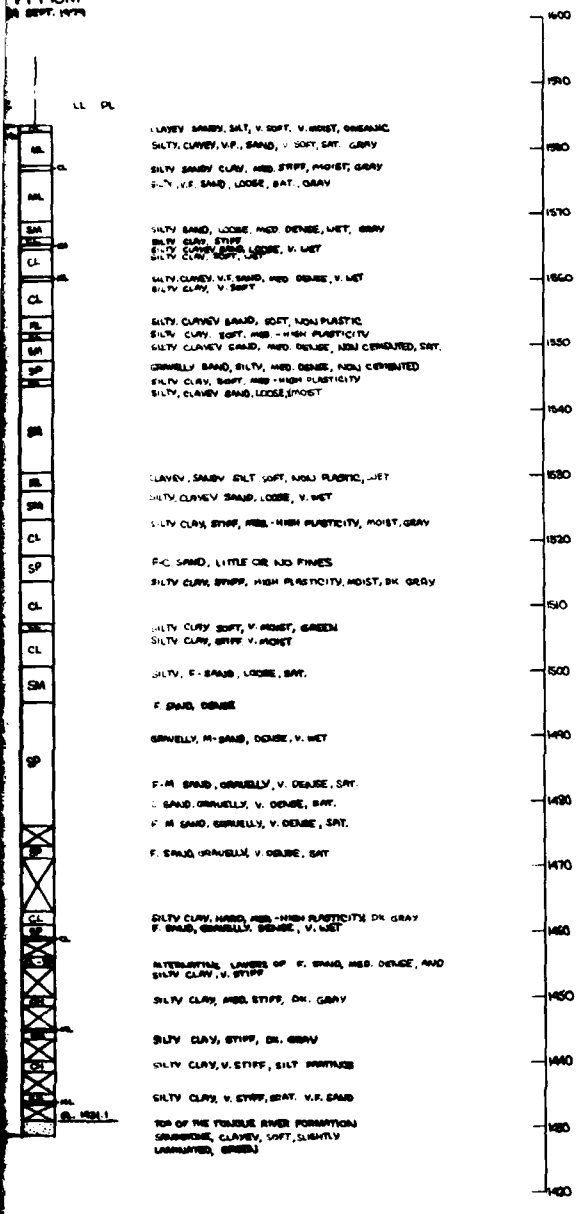
SHEET OF

PLATE NO B-18

2


79-144M
9-21 SEPT. 1979
BLOWS/FT (STD.)
MC
LL PL
EL 1582.7
EL 1578.4
EL 1488.5
SANDY SILTY CLAY, SOFT, NON PLASTICITY, DRY, V. ORGANIC (ROOTS)
SILTY SAND, LOOSE, MOIST
CLAYEY SILT, SOFT, LOW PLASTICITY, MOIST
SILTY CLAY, MED. STIFF, MED. PLASTICITY, MOIST
CLAYEY SANDY SILT, SOFT, LOW PLASTICITY, V. MOIST
SILTY CLAY, MED. STIFF, LOW PLASTICITY, MOIST
SILTY CLAY, SANDY, STIFF, MED. PLASTICITY
SILTY SAND, LOOSE, SAT.
SILTY CLAY, MED. STIFF, LOW PLASTICITY, WET, SLIGHTLY ORGANIC
SILTY CLAY, SANDY, MED. STIFF, LOW PLASTICITY, V. MOIST
SILTY CLAY, MED. STIFF, MED. - HIGH PLASTICITY, MOIST
CLAYEY SANDY SILT, SOFT - MED. STIFF, V. MOIST
SILTY SAND, LOOSE, SAT.
GRAVELLY SAND, LOOSE, SAT., DK. GRAY
SILTY CLAY, MED. STIFF, HIGH PLASTICITY, MOIST
SILTY CLAY, SOFT - MED. STIFF, MOIST, GRAY
SILTY SAND, LOOSE, SAT.
CLAYEY SILT, MED. STIFF, MOIST, LT. GRAY
SILT, V. SOFT, V. WET
SILTY CLAY, MED. STIFF, MED. - HIGH PLASTICITY, MOIST,
SAND, LOOSE, SAT.
SILTY CLAY, STIFF, MOIST
SILTY CLAY, STIFF, MED. - HIGH PLASTICITY, V. MOIST
CLAYEY SILT, SOFT, WET
SILTY CLAY, MED. STIFF - STIFF, MED. - HIGH PLASTICITY, MOIST
CLAYEY SILT, SOFT, NON PLASTIC, WET
CLAYEY SAND, V. STIFF, NON-PLASTIC, MOIST
SILTY CLAY, STIFF, MOIST, LT. BROWN
V.F. SAND, SILTY, MED. DENSE, NON PLASTIC, SAT., GRY
SILTY CLAYEY SAND, MED. DENSE, SLIGHTLY CEMENTED, SAT., GRAY
TOP OF THE TONGUE RIVER FORMATION
SANDSTONE, CLAYEY, V. SOFT, LT. GREENISH-GRAY
LIGNITE, SOFT, FRACTURED, BLACK
79-145M
21-24 SEPT. 1979
BLOWS/FT. (STD.)
MC
LL PL
EL 1493
EL 1491.5
EL 1432.9
EL 1431.1
CLAYEY SANDY SILT, V. SOFT, V. MOIST, ORGANIC
SILTY CLAYEY, V.F., SAND, SOFT, SAT., GRAY
SILTY SANDY CLAY, MED. STIFF, MOIST, GRAY
F-C, V.F. SAND, LOOSE, SAT., GRAY
SILTY SAND, LOOSE, MED. DENSE, WET, GRAY
SILTY CLAY, STIFF
SILTY CLAYEY SAND, LOOSE, V. WET
SILTY CLAY, SOFT, WET
SILTY CLAYEY, V.F. SAND, MED. DENSE, V. WET
SILTY CLAY, V. SOFT
SILTY CLAYEY SAND, SOFT, NON PLASTIC
SILTY CLAY, SOFT, MED. - HIGH PLASTICITY
SILTY CLAYEY SAND, MED. DENSE, NON CEMENTED, SAT.
GRAVELLY SAND, SILTY, MED. DENSE, NON CEMENTED
SILTY CLAY, SOFT, MED. - HIGH PLASTICITY
SILTY, CLAYEY SAND, LOOSE, WET
CLAYEY, SANDY SILT, SOFT, NON PLASTIC, WET
SILTY, CLAYEY SAND, LOOSE, V. WET
SILTY CLAY, STIFF, MED. - HIGH PLASTICITY, MOIST, GRAY
F-C SAND, LITTLE OR NO FINES
SILTY CLAY, STIFF, HIGH PLASTICITY, MOIST, DK. GRAY
SILTY CLAY, SOFT, V. MOIST, GREEN
SILTY CLAY, STIFF, V. MOIST
SILTY, F-C SAND, LOOSE, SAT.
F SAND, DENSE
GRAVELLY, M-C SAND, DENSE, V. WET
F-M SAND, GRAVELLY, V. DENSE, SAT.
F SAND, GRAVELLY, V. DENSE, SAT.
F-M SAND, GRAVELLY, V. DENSE, SAT.
F SAND, GRAVELLY, V. DENSE, SAT.
SILTY CLAY, HARD, MED. - HIGH PLASTICITY, DK. GRAY
F SAND, GRAVELLY, DENSE, V. WET
ALTERNATING LAYERS OF F. SAND, MED. DENSE, AND SILTY CLAY, V. STIFF
SILTY CLAY, MED. STIFF, DK. GRAY
SILTY CLAY, STIFF, DK. GRAY
SILTY CLAY, V. STIFF, SILT PARTICLES
SILTY CLAY, V. STIFF, SAT., V.F. SAND
TOP OF THE TONGUE RIVER FORMATION
SANDSTONE, CLAYEY, SOFT, SLIGHTLY LAMINATED, GREEN

79-145M
SEPT. 1979



DIVISION	DESCRIPTION	DATE	APPROVED

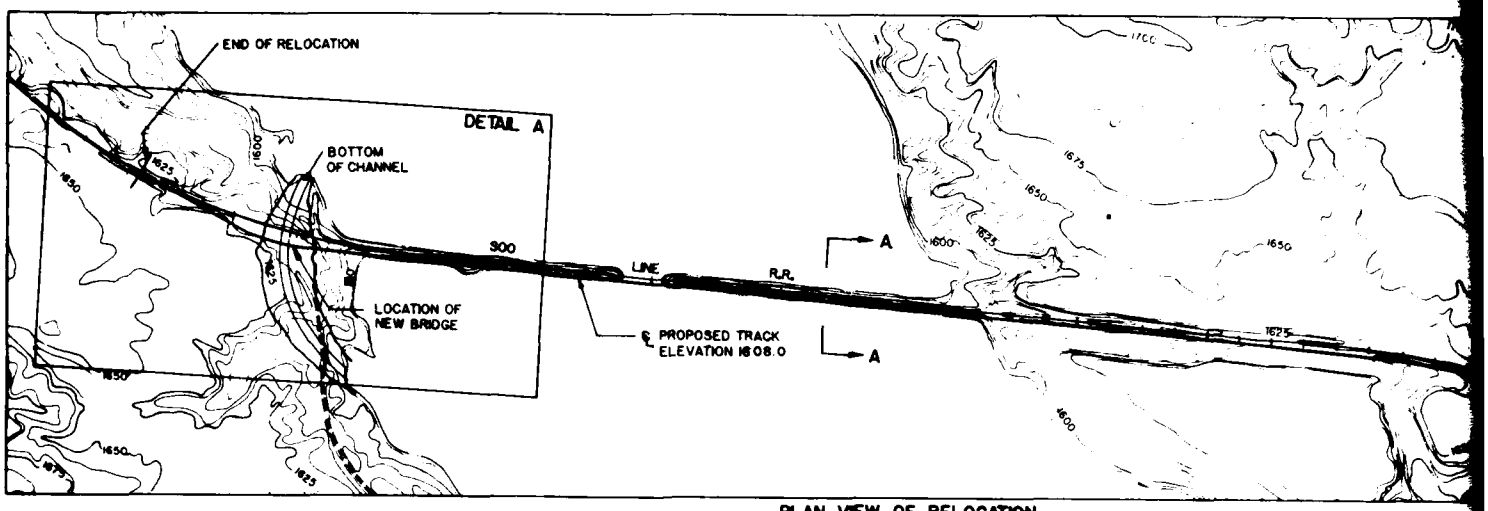
DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
ST PAUL, MINNESOTA

DESIGNED BY: L.H.B.	DESIGN MEMORANDUM NO. 3 GENERAL
DRAWN BY: L.H.B.	FLOOD CONTROL - LAKE DARLING
TRACED BY: M.M.B.	SOURIS RIVER, NORTH DAKOTA
SUBMITTED BY:	LAKE DARLING DAM
	79-144M AND 79-145M
APPROVED:	DATE: JUNE 1983
	DRAWING NUMBER: RI-R-5/718
	SHEET OF

SAFETY PAYS

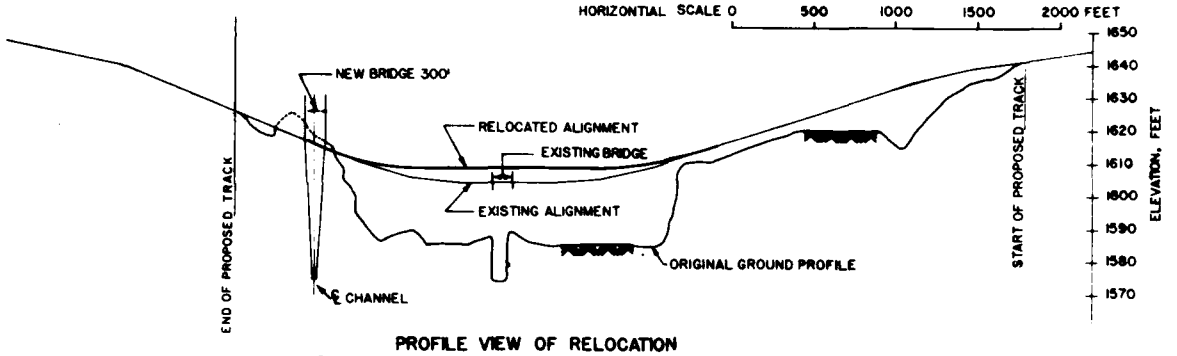
PLATE NO. B-19

1 2



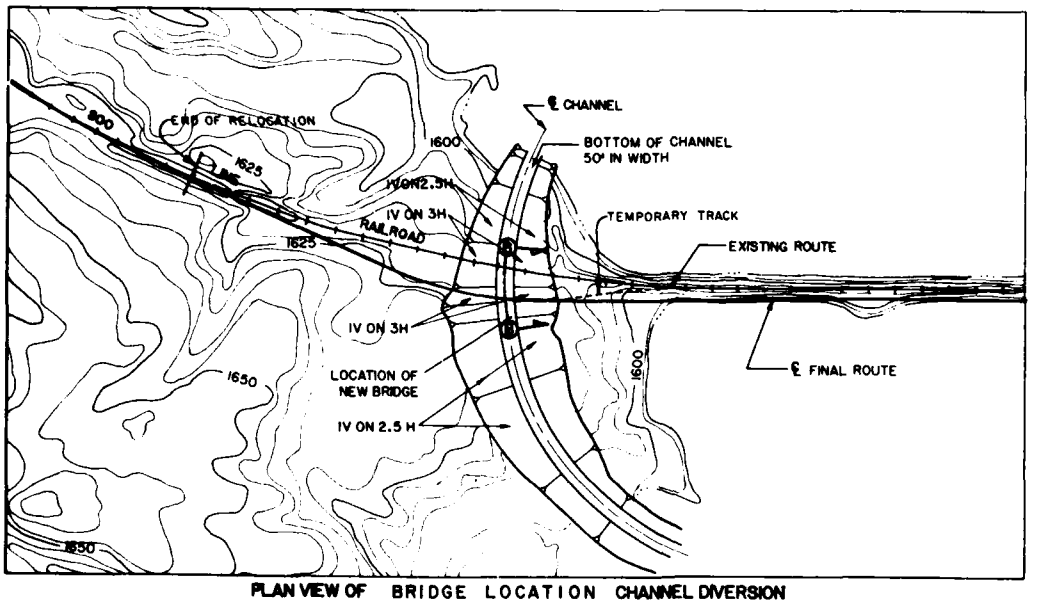
PLAN VIEW OF RELOCATION

HORIZONTAL SCALE 0 500 1000 1500 2000 FEET



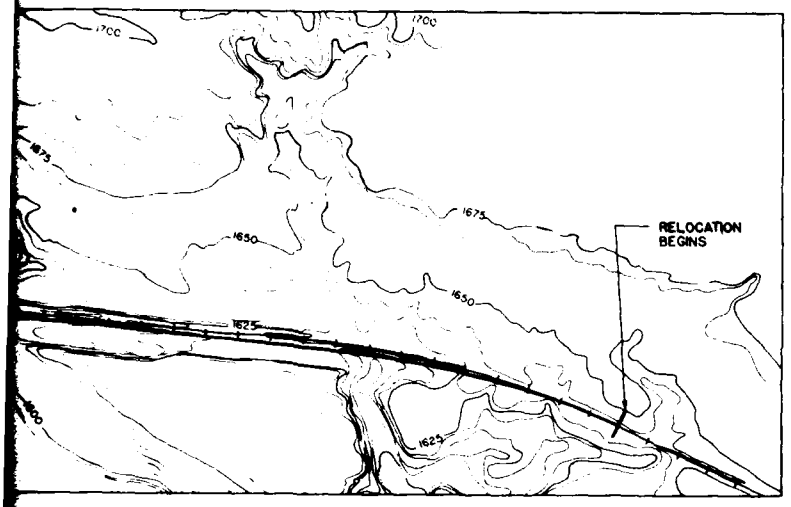
PROFILE VIEW OF RELOCATION

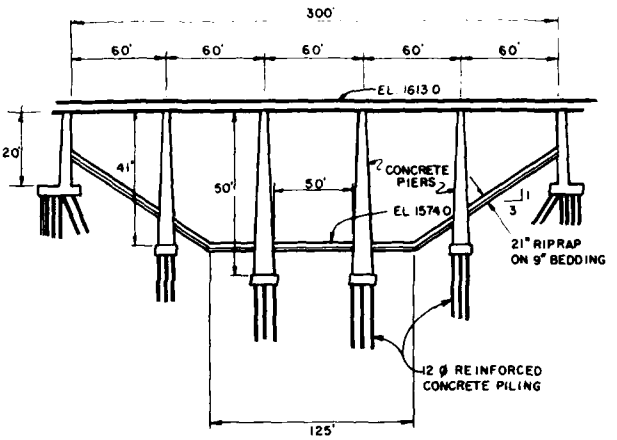
SCALE 0 1000 2000 3000 4000 FEET

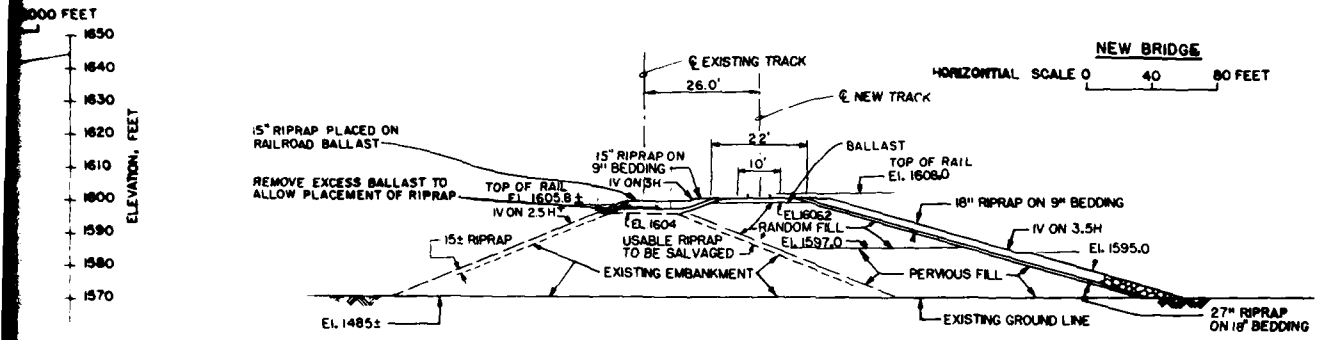


PLAN VIEW OF BRIDGE LOCATION CHANNEL DIVERSION DETAIL A

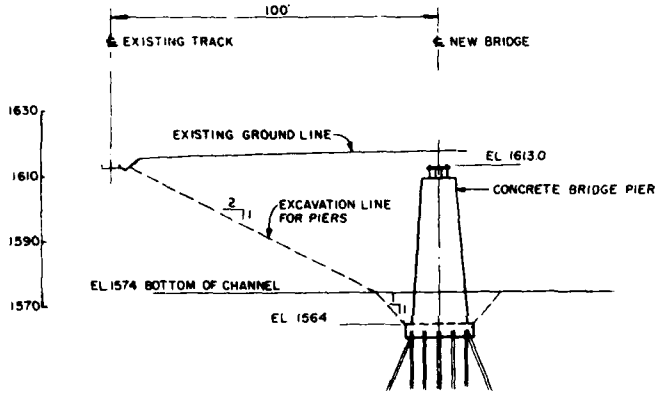
SCALE 0 100 300 500 FEET







SECTION A-A
TYPICAL EMBANKMENT
SCALE 20' 0 20' FEET



SECTION B-B
SCALE 20' 0 20' FEET

SAFETY PAYS

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
ST PAUL, MINNESOTA

DESIGNED BY R.G.T. C.C.
DRAWN BY JU
CHECKED BY G.R.S. M.B.
SUBMITTED BY
APPROVED

DESIGN MEMORANDUM NO 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
SOO LINE RAILROAD
RELOCATION

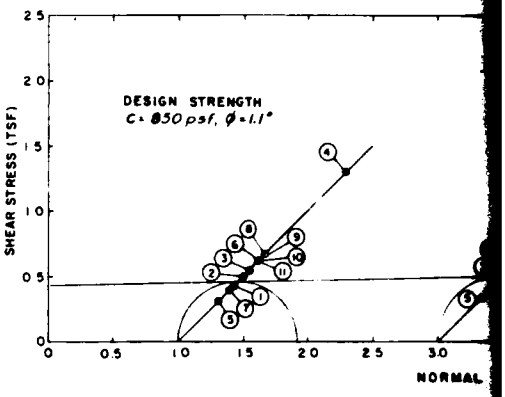
DATE JUNE 1983
SCALE AS SHOWN
DRAWING NUMBER NI-R-5/719
SHEET OF

PLATE NO. B-20

1 2

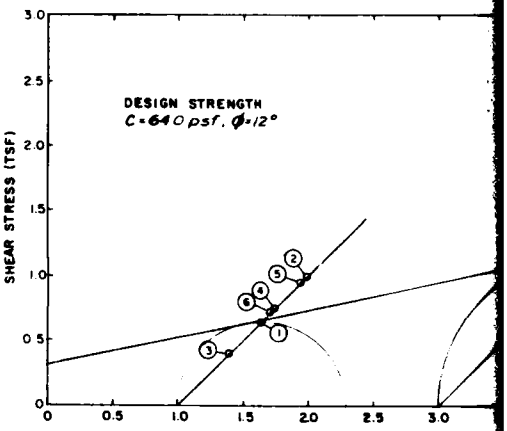
Q-TESTS

TEST No.	BORING No.	SAMPLE No.	MOISTURE CONTENT %	LIQUID LIMIT	PLASTIC LIMIT	AVG VOIDS RATIO	INITIAL SATURATION %
1	76-75MU	S-1	28.7	42	19	0.837	91.7
2	76-75MU	S-2	29.5	48	17	0.803	98.0
3	76-75MU	S-3	33.8	62	21	0.903	99.0
4	76-75MU	S-5	26.5	36	17	0.733	97.0
5	76-75MU	S-7	44.9	20	18	0.640	100.0
6	76-77MU	S-2	28.4	53	20	0.873	88.3
7	76-77MU	S-3	39.1	56	19	1.063	99.3
8	76-77MU	S-4	32.2	66	23	0.897	96.3
9	76-77MU	S-5	34.5	85	26	1.020	93.0
10	76-77MU	S-6	35.6	64	23	1.003	96.3
11	76-77MU	S-7	32.1	52	20	0.930	94.3



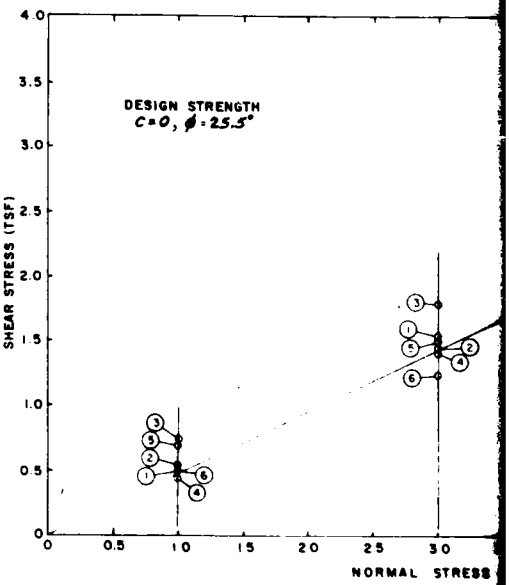
R-TESTS

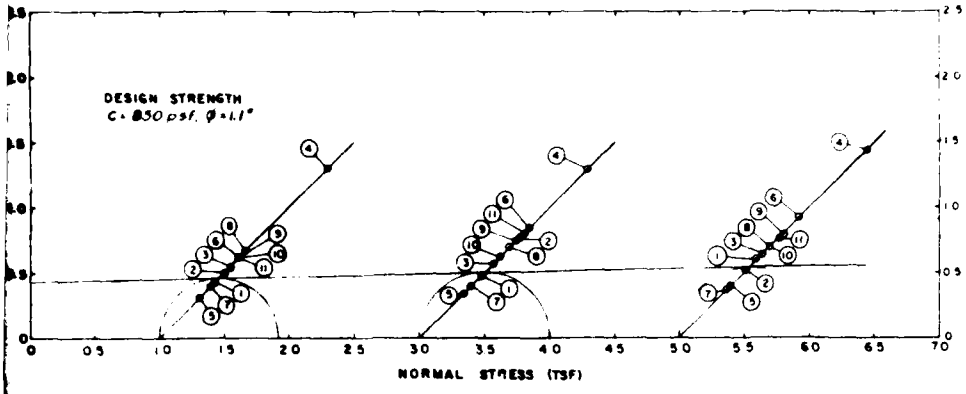
TEST No.	BORING No.	SAMPLE No.	MOISTURE CONTENT %	LIQUID LIMIT	PLASTIC LIMIT	AVG. VOIDS RATIO	INITIAL SATURATION %
1	76-75MU	S-2	28.4	48	17	0.787	96.3
2	76-75MU	S-5	25.2	36	17	0.717	94.7
3	76-77MU	S-1	34.6	49	20	1.100	85.0
4	76-77MU	S-2	31.8	53	20	0.920	94.7
5	76-77MU	S-4	32.8	66	23	0.887	99.3
6	76-77MU	S-6	33.8	64	23	0.943	97.0

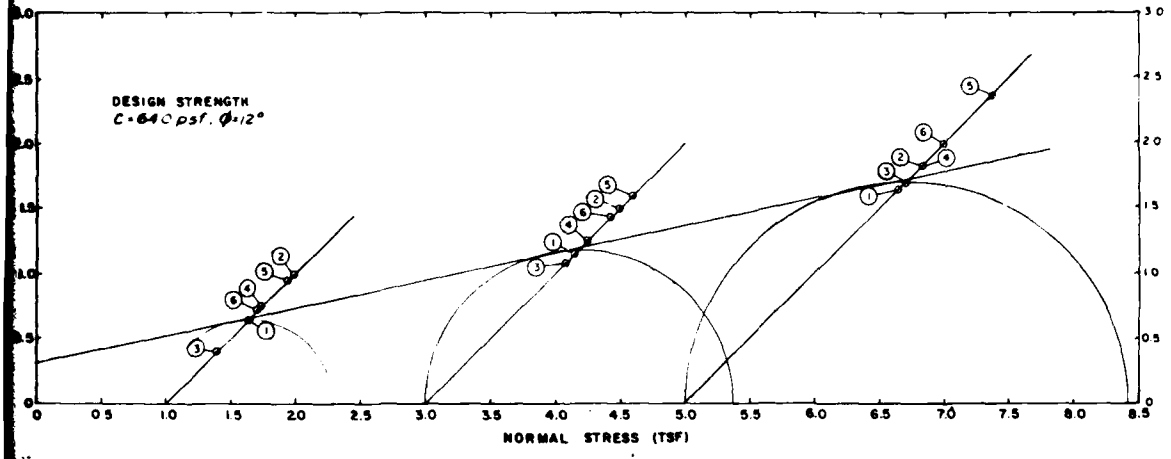


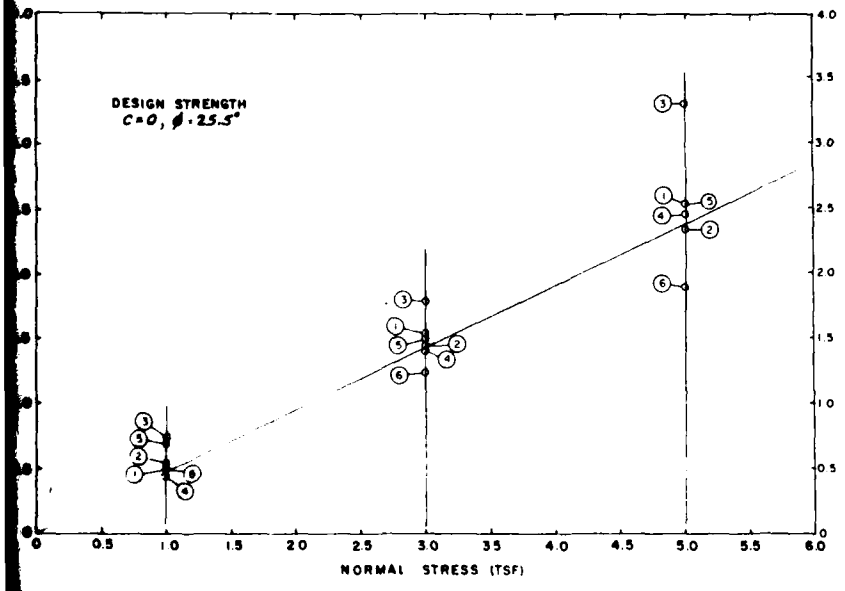
S-TESTS

TEST No.	BORING No.	SAMPLE No.	MOISTURE CONTENT %	LIQUID LIMIT	PLASTIC LIMIT	AVG. VOIDS RATIO	INITIAL SATURATION %
1	76-75MU	S-2	32.3	48	17	0.940	91.7
2	76-75MU	S-3	36.8	62	21	1.020	95.3
3	76-75MU	S-5	26.9	36	17	0.837	86.7
4	76-77MU	S-1	35.0	49	20	1.210	78.3
5	76-77MU	S-2	29.0	53	20	0.937	84.7
6	76-77MU	S-5	35.3	85	26	1.077	90.7









SAFETY PAYS

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

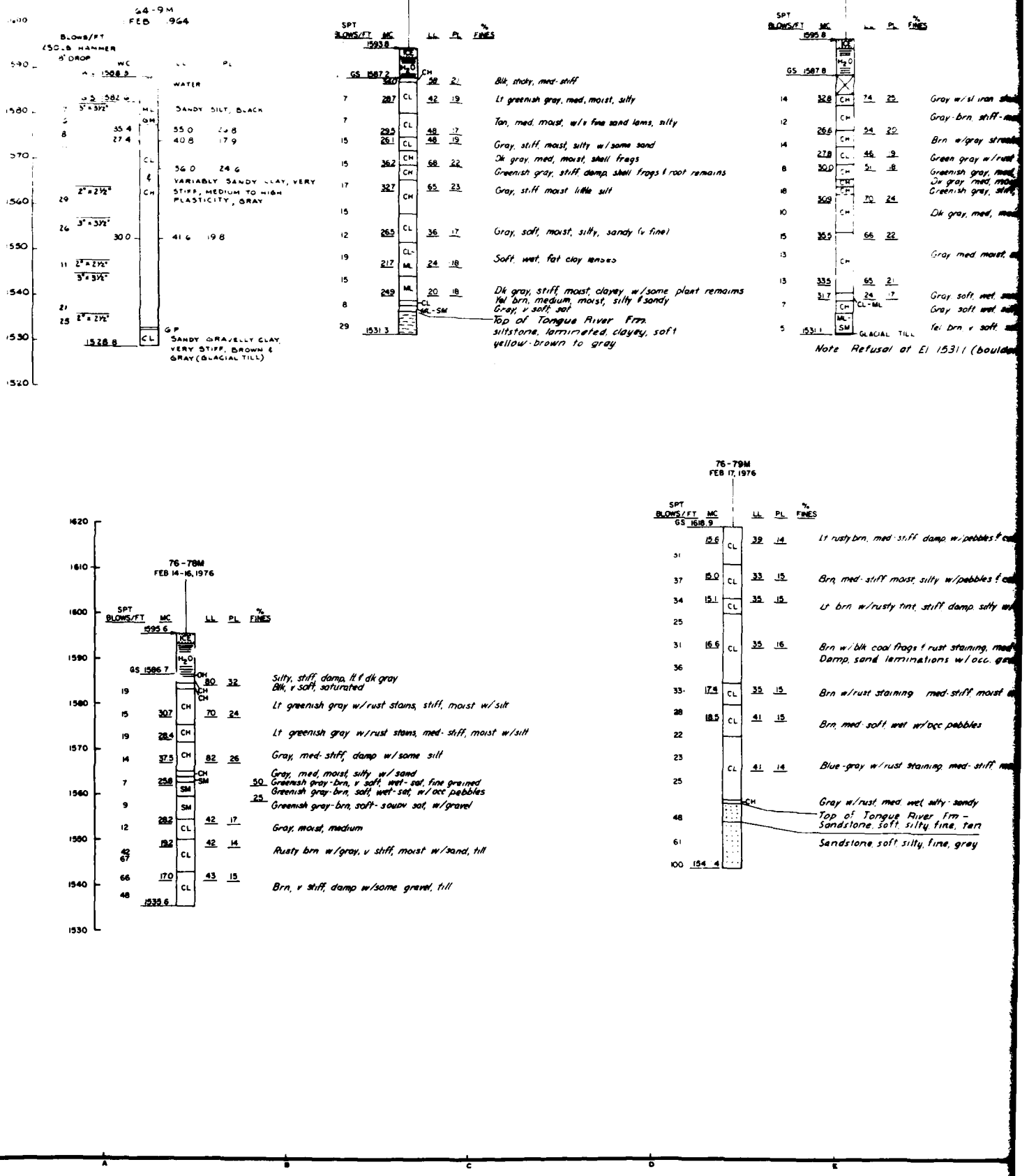
DESIGNED BY: M.B.
DRAWN BY: D.A.E.
TRACED BY: L.D.
SUBMITTED BY:
APPROVED:

DESIGN MEMORANDUM NO. 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
SOO LINE RAILROAD
FOUNDATION STRENGTHS

DATE: JUNE 1963
SCALE: AS SHOWN
DRAWING NUMBER: RI-R-5/720
SHEET OF

PLATE NO. B-21


64-9M
FEB 1964
BLOWS/FT
(50 LB HAMMER
8" DROP
WC
LL
PL
WATER
Sandy Silt, Black
Variably Sandy Clay, very stiff, medium to high plasticity, gray
GP
Sandy Gravelly Clay, very stiff, brown & gray (glacial till)
76-75M
FEB 9-10, 1976
SPT
BLOWS/FT
MC
LL
PL
% FINES
Blk, sticky, med-stiff
Lt greenish gray, med, moist, silty
Tan, med, moist, w/s fine sand lams, silty
Gray, stiff, moist, silty w/some sand
Dk gray, med, moist, shell frags
Greenish gray, stiff, damp, shell frags & root remains
Gray, stiff moist little silt
Gray, soft, moist, silty, sandy (v fine)
Soft, wet, fat clay lenses
Dk gray, stiff, moist, clayey w/some plant remains
Yel brn, medium, moist, silty & sandy
Gray, v soft, sat
Top of Tongue River Frm.
siltstone, laminated, clayey, soft
yellow-brown to gray
76-76M
FEB 11-12 1976
Gray w/sl iron
Gray-brn, stiff-
Brn w/gray
Green gray w/rust
Greenish gray, med,
Dk gray med, mod
Greenish gray, stiff,
Dk gray, med,
Gray med moist,
Gray, soft, wet,
Gray soft wet
Yel brn v soft,
Glacial Till
Note Refusal at El 1531.1 (boulde
76-78M
FEB 14-16, 1976
Silty, stiff, damp, lt & dk gray
Blk, v soft, saturated
Lt greenish gray w/rust stains, stiff, moist w/silt
Lt greenish gray w/rust stains, med-stiff, moist w/silt
Gray, med-stiff, damp w/some silt
Gray, med, moist, silty w/sand
Greenish gray-brn, v soft, wet-sat, fine grained
Greenish gray-brn, soft, wet-sat, w/occ pebbles
Greenish gray-brn, soft-sourv sat, w/gravel
Gray, moist, medium
Rusty brn w/gray, v stiff, moist w/sand, till
Brn, v stiff, damp w/some gravel, till
76-79M
FEB 17, 1976
Lt rusty brn, med-stiff, damp w/pebbles &
Brn, med-stiff moist, silty w/pebbles &
Lt brn w/rusty tint, stiff, damp, silty
Brn w/blk coal frags & rust staining, mod
Damp, sand laminations w/occ. gra
Brn w/rust staining med-stiff, moist
Brn, med-soft, wet w/occ pebbles
Blue-gray w/rust staining, med-stiff,
Gray w/rust, med, wet, silty-sandy
Top of Tongue River Frm -
Sandstone, soft, silty, fine, tan
Sandstone, soft, silty, fine, gray

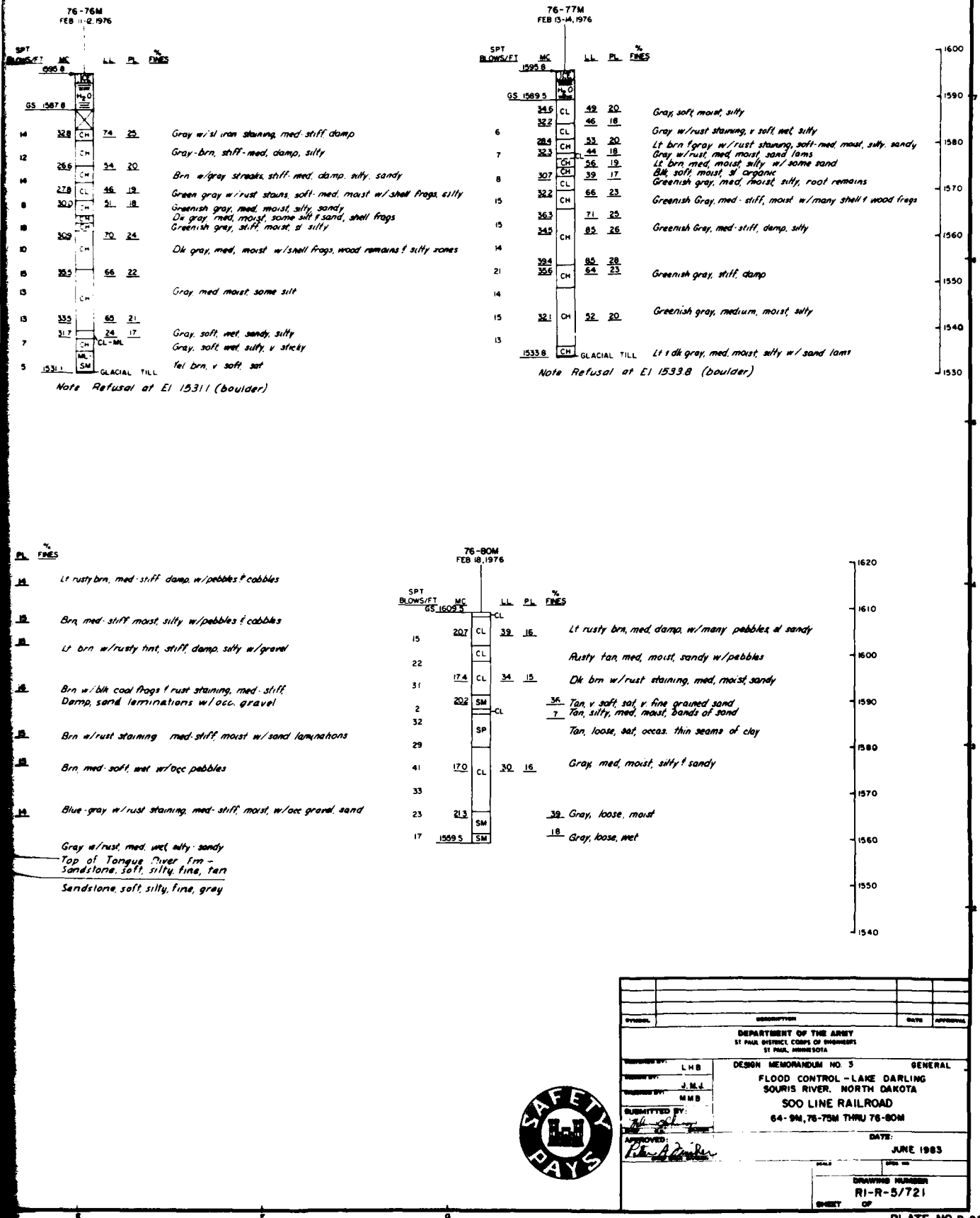
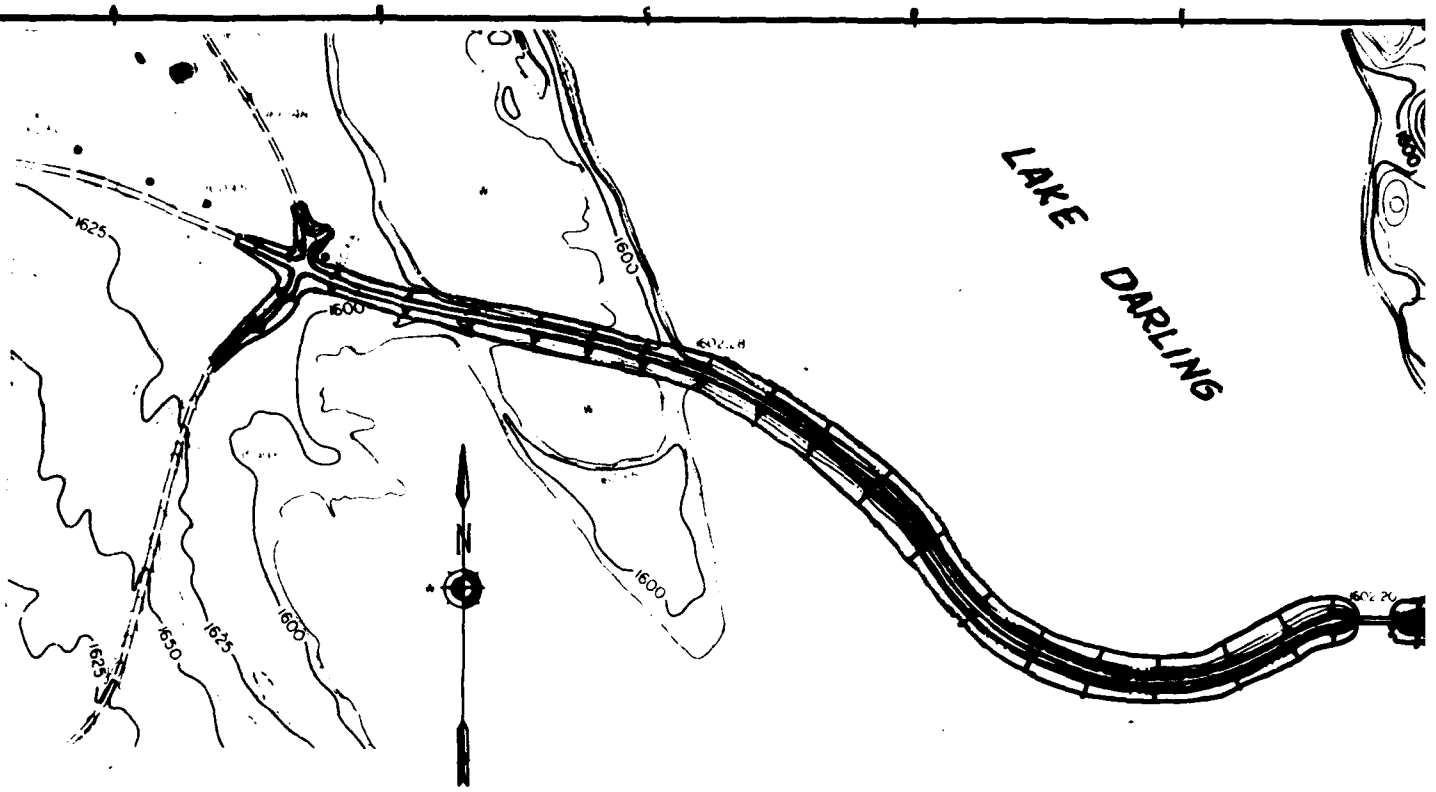
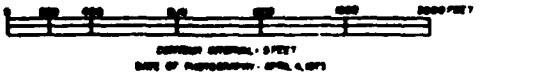
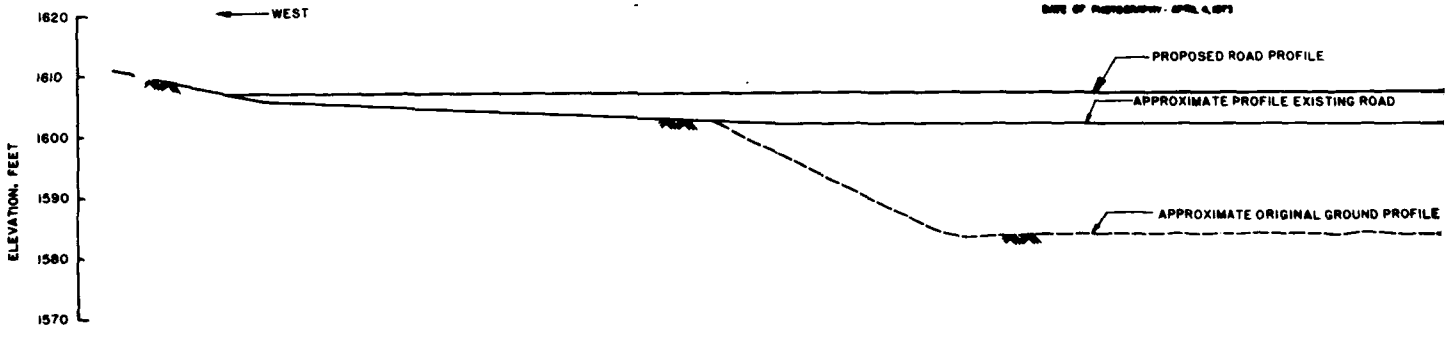

76-76M
FEB 11-12, 1976
SPT BLOWS/FT
MC
LL
PL
% FINES
GS 1587.8
GS 1589.5
Gray w/sl iron staining, med-stiff, damp
Gray-brn, stiff-med, damp, silty
Brn w/gray streaks, stiff-med, damp, silty, sandy
Green gray w/rust stains, soft-med, moist w/shell frags, silty
Greenish gray, med, moist, silty, sandy
Dk gray, med, moist, some silt & sand, shell frags
Greenish gray, stiff, moist, sl silty
Dk gray, med, moist w/shell frags, wood remains & silty zones
Gray, med moist, some silt
Gray, soft, wet, sandy, silty
Gray, soft, wet, silty, v sticky
Yel brn, v soft, sat
GLACIAL TILL
Note Refusal at El 1531.1 (boulder)
76-77M
FEB 13-14, 1976
1595.8
Gray, soft, moist, silty
Gray w/rust staining, v soft, wet, silty
Lt brn & gray w/rust staining, soft-med, moist, silty, sandy
Gray w/rust, med, moist, sand lams
Lt brn, med, moist, silty w/some sand
Blk, soft, moist, sl organic
Greenish gray, med, moist, silty, root remains
Greenish Gray, med-stiff, moist w/many shell & wood frags
Greenish Grey, med-stiff, damp, silty
Greenish gray, stiff, damp
Greenish gray, medium, moist, silty
Lt & dk gray, med, moist, silty w/sand lams
1533.8
GLACIAL TILL
Note Refusal at El 1533.8 (boulder)
1600
1590
1580
1570
1560
1550
1540
1530
76-80M
FEB 18, 1976
GS 1609.5
Lt rusty brn, med, damp, w/many pebbles, sl sandy
Rusty tan, med, moist, sandy w/pebbles
Dk brn w/rust staining, med, moist, sandy
Tan, v soft, sat, v fine grained sand
Tan, silty, med, moist, bands of sand
Tan, loose, sat, occas. thin seams of clay
Gray, med, moist, silty & sandy
Gray, loose, moist
Gray, loose, wet
1559.5
1620
1610
1600
1590
1580
1570
1560
1550
1540
Lt rusty brn, med-stiff, damp, w/pebbles & cobbles
Brn, med-stiff, moist, silty w/pebbles & cobbles
Lt brn w/rusty tint, stiff, damp, silty w/gravel
Brn w/blk coal frags & rust staining, med-stiff, Damp, sand laminations w/occ. gravel
Brn w/rust staining med-stiff, moist w/sand laminations
Brn, med-soft, wet w/occ pebbles
Blue-gray w/rust staining, med-stiff, moist, w/occ gravel, sand
Gray w/rust, med, wet, silty-sandy
Top of Tongue River Fm - Sandstone, soft, silty, fine, tan
Sandstone, soft, silty, fine, gray
DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
ST PAUL, MINNESOTA
DESIGN MEMORANDUM NO. 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
SOO LINE RAILROAD
64-9M, 76-75M THRU 76-80M
DESIGNED BY: LHB
DRAWN BY: J.M.J
CHECKED BY: MMB
SUBMITTED BY:
APPROVED:
DATE: JUNE 1983
DRAWING NUMBER
RI-R-5/721
SAFETY PAYS

PLATE NO. B-22

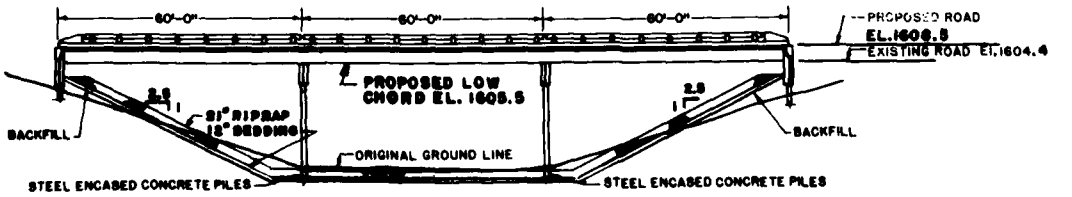


PLAN

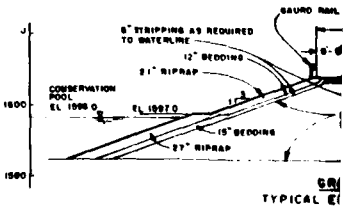


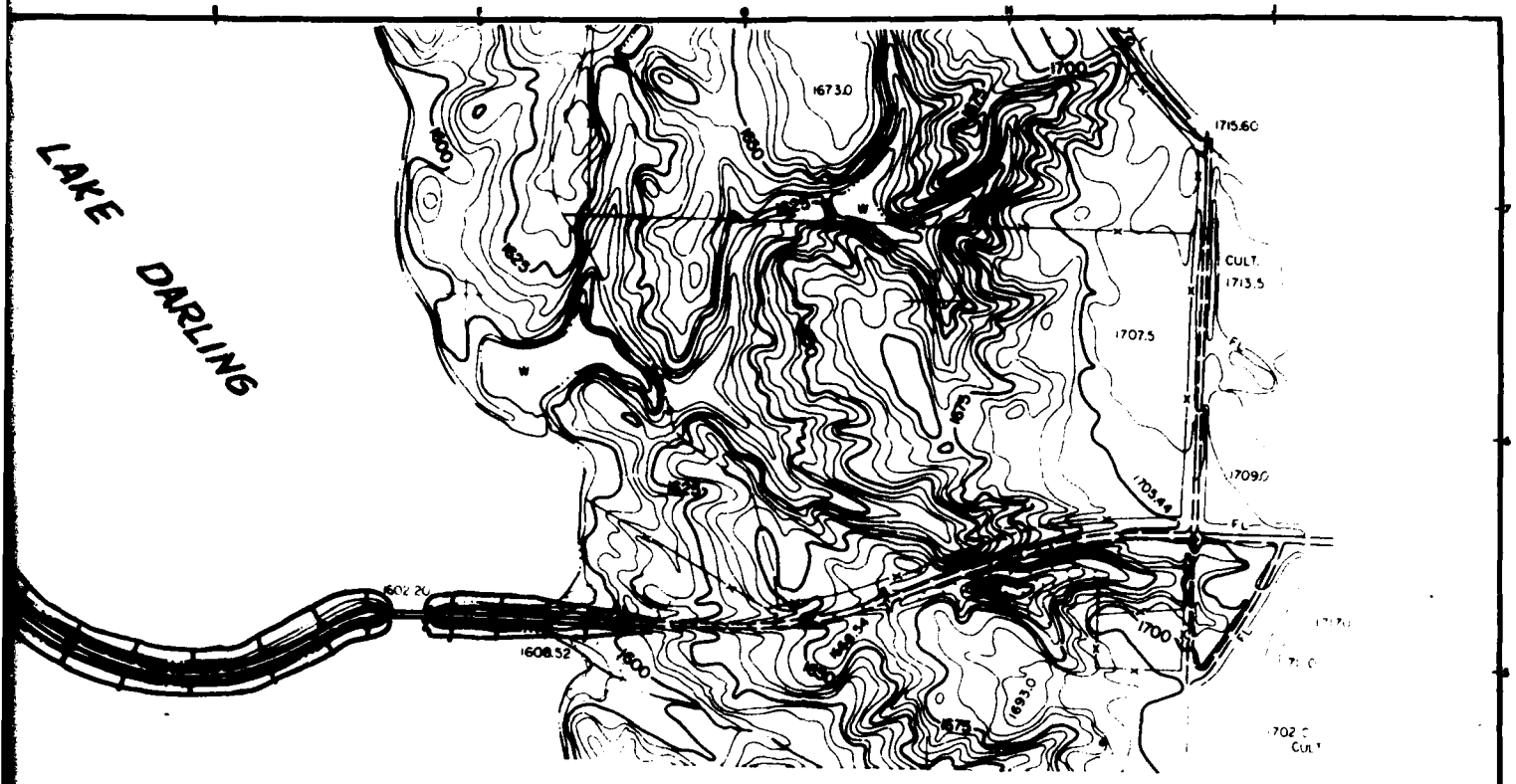


PROFILE
GRAND CROSSING BRIDGE RAISE
SCALE 0 100 500 1000 FEET

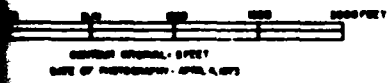


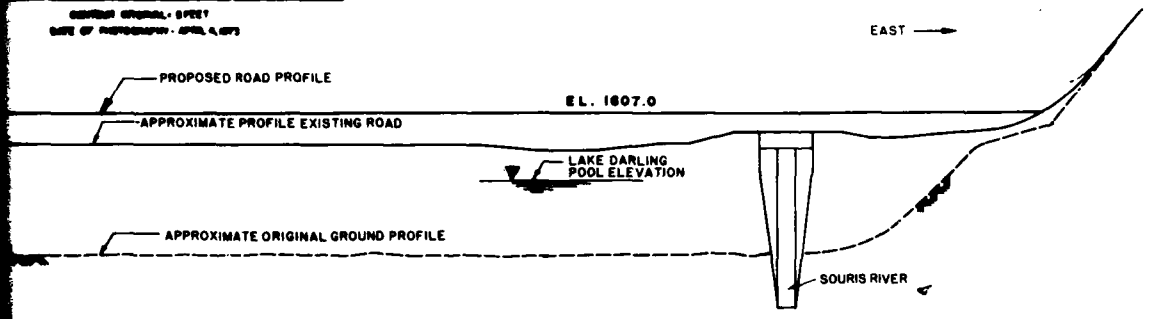
ELEVATION
GRAND CROSSING BRIDGE RAISE
NOT TO SCALE





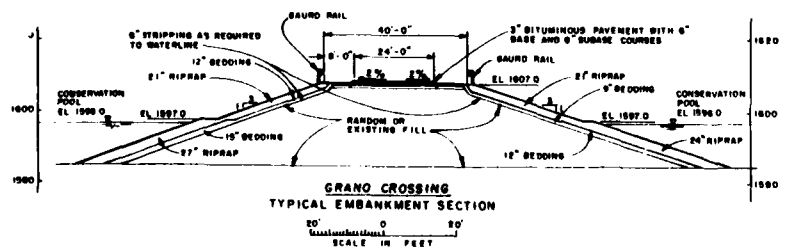
PLAN





PROFILE
SSING BRIDGE RAISE

500 1000 FEET



GRAND CROSSING
TYPICAL EMBANKMENT SECTION

20' 0 20'
SCALE IN FEET

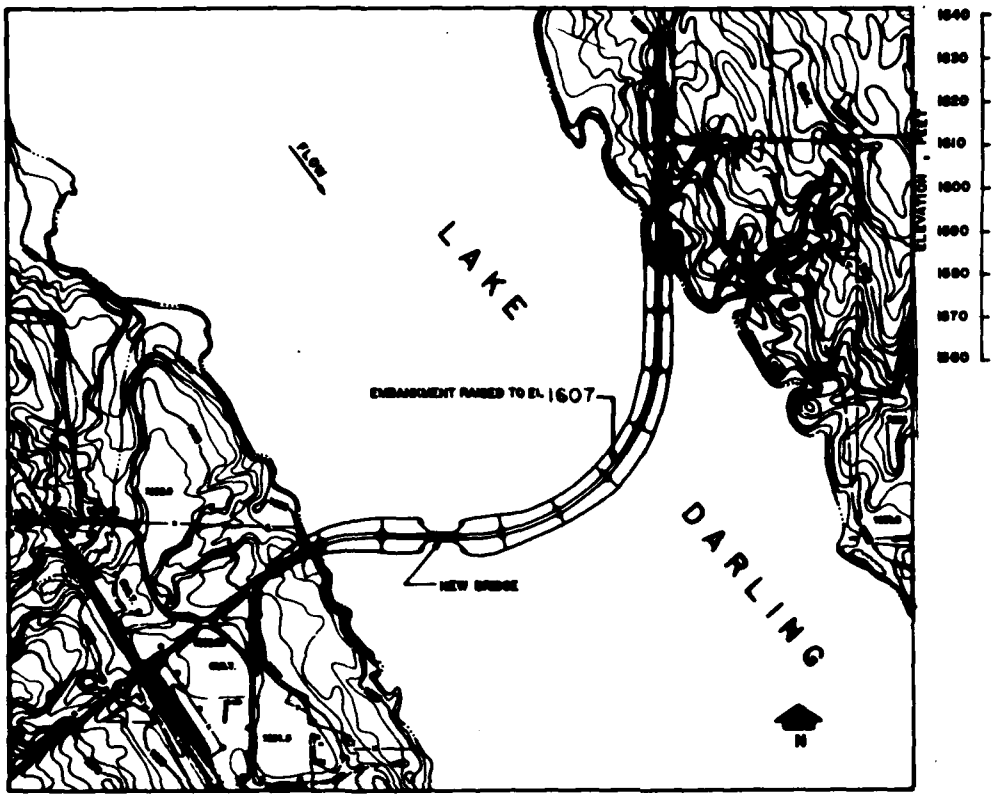
SAFETY PAYS

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT CORPS OF ENGINEERS
ST PAUL MINNESOTA

DESIGNED BY B.J.B.
DRAWN BY J.M.J.
CHECKED BY G.R.S.
SUBMITTED BY
APPROVED

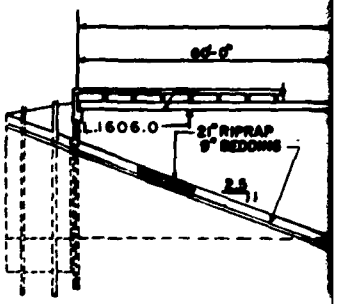
DESIGN MEMORANDUM NO 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
GRAND CROSSING
RELOCATION
DATE
JUNE 1963
SCALE
AS SHOWN
DRAWING NUMBER
RI-R-5/722
SHEET OF

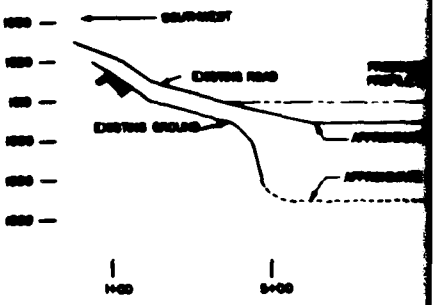
PLATE B-23

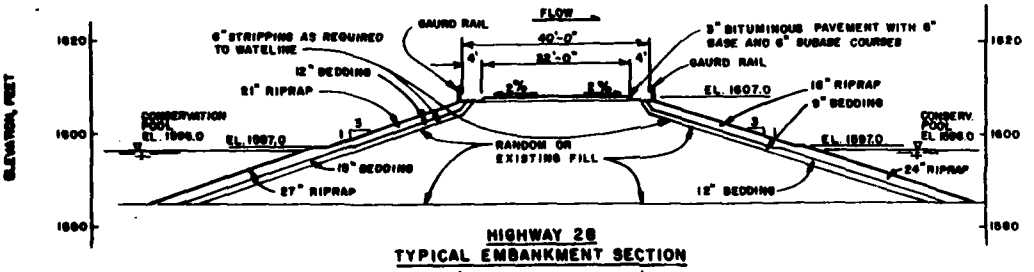


PLAN

SCALE 0 400 800 FEET



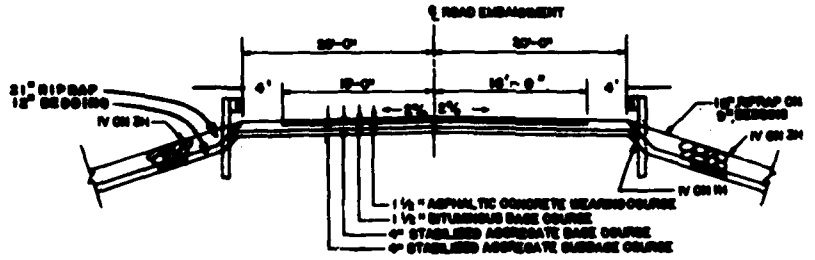




HIGHWAY 28
TYPICAL EMBANKMENT SECTION

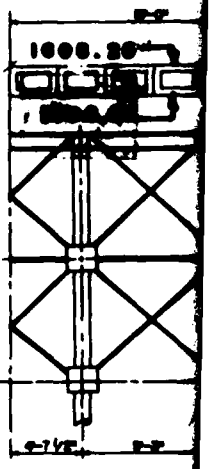
20' 0 20'

SCALE IN FEET

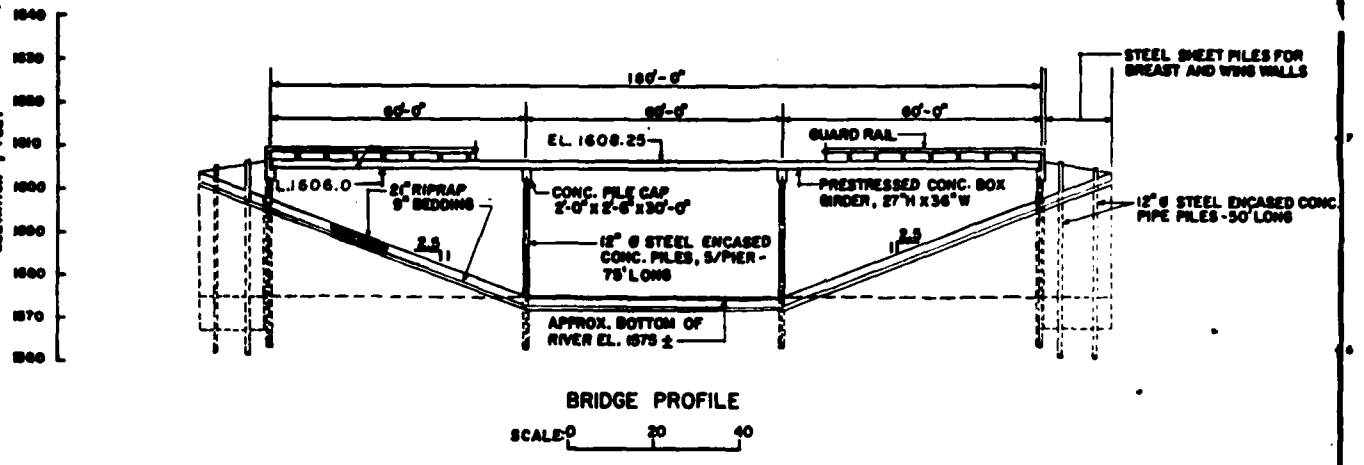


NOT TO SCALE

DETAIL A

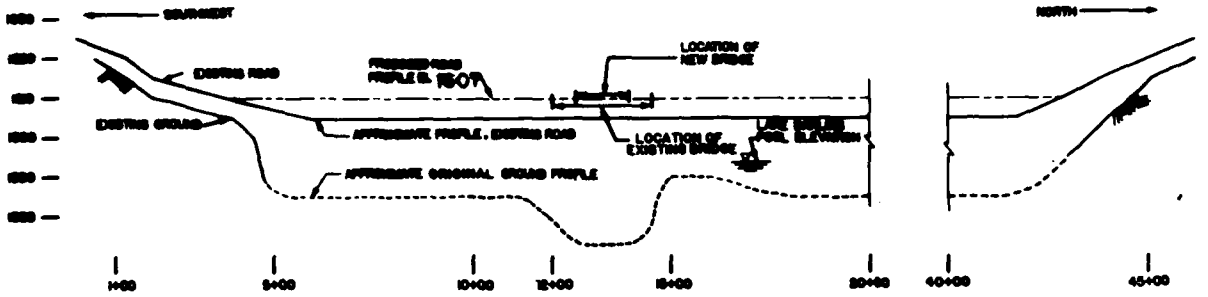


TYPICAL HALF
SCALE 0 4

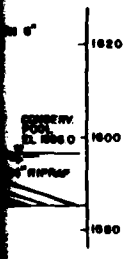


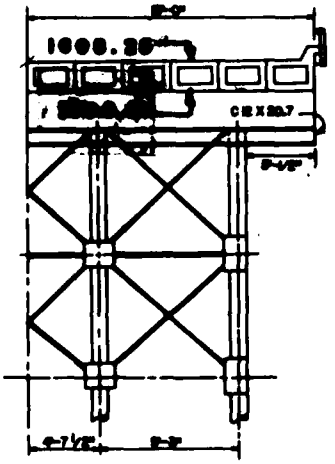
BRIDGE PROFILE

SCALE 0 20 40



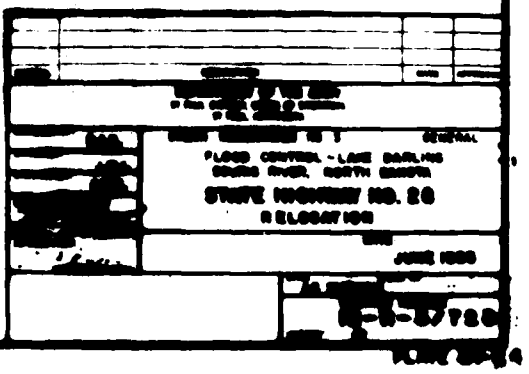
PROFILE STATE HIGHWAY 20 RAISE

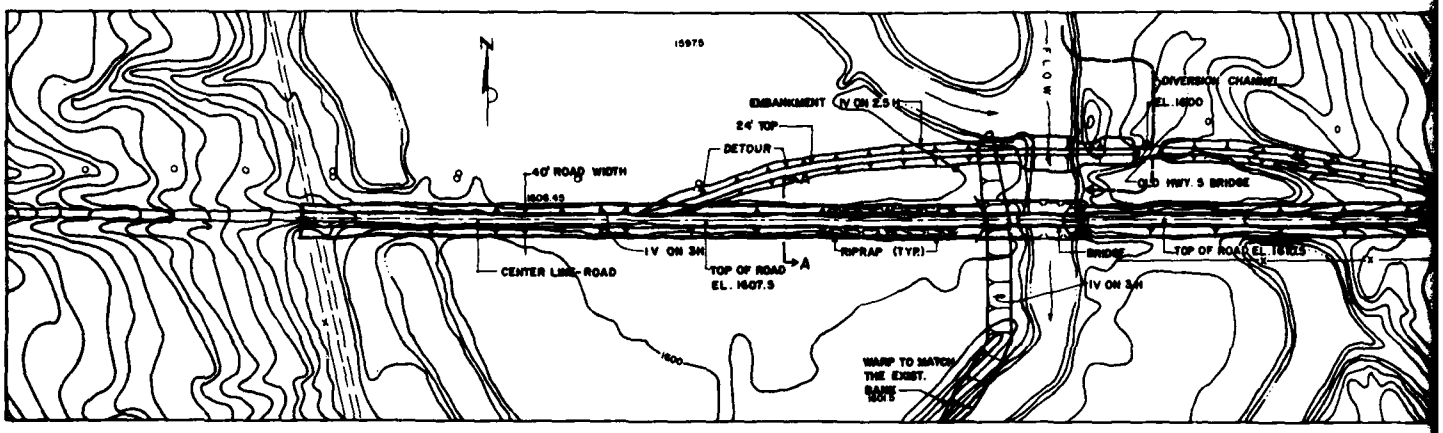




TYPICAL HALF PIER SECTION

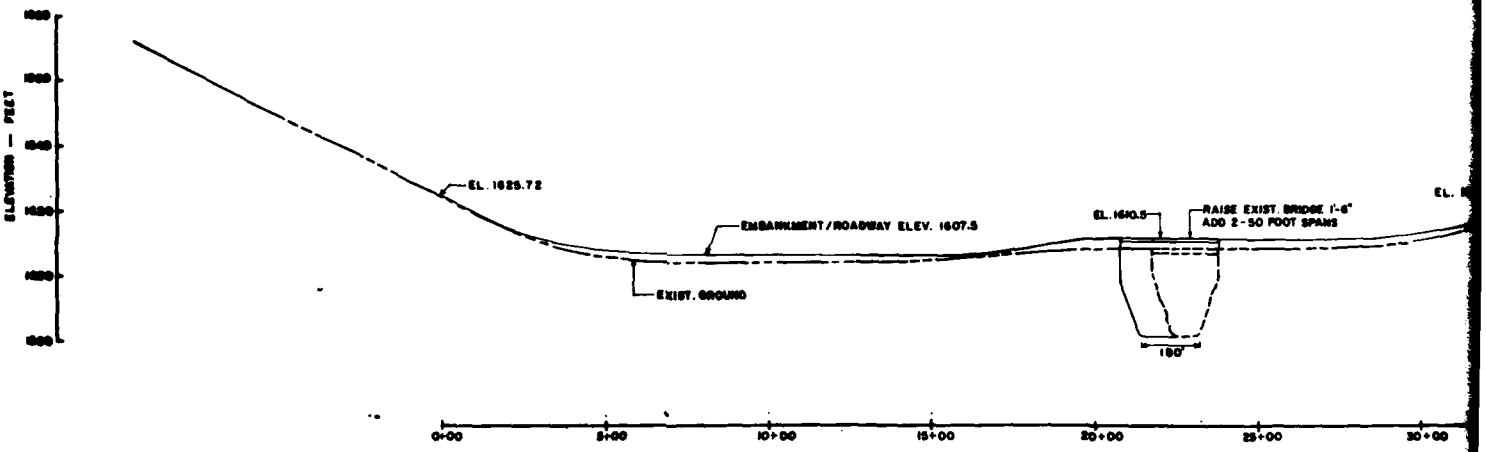
SCALE 0 4 8 FEET





ROAD RAISE PLAN

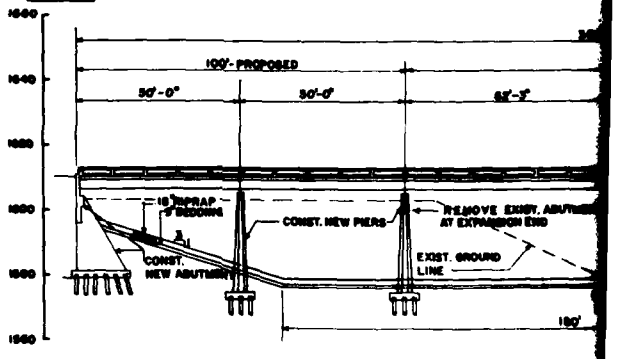
SCALE 0 200'



PROFILE

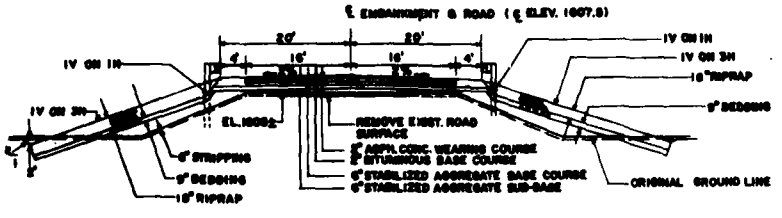
HORIZ. SCALE 0 200'

VERT. SCALE 0 20'



PROFILE OF RAIS

SCALE 0

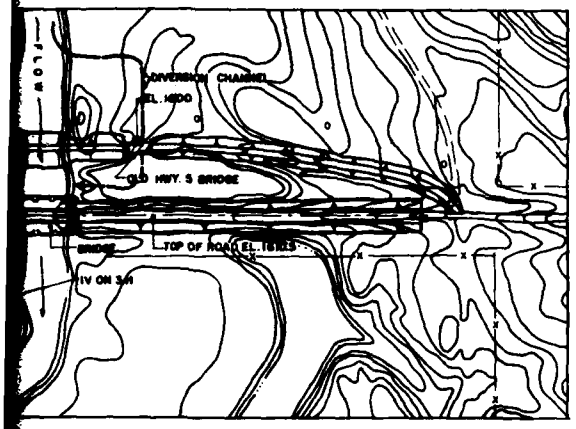


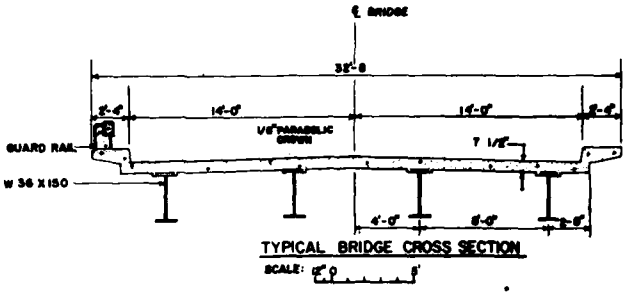
SECTION A-A

TYPICAL EMBANKMENT SECTION

HWY NO. 5

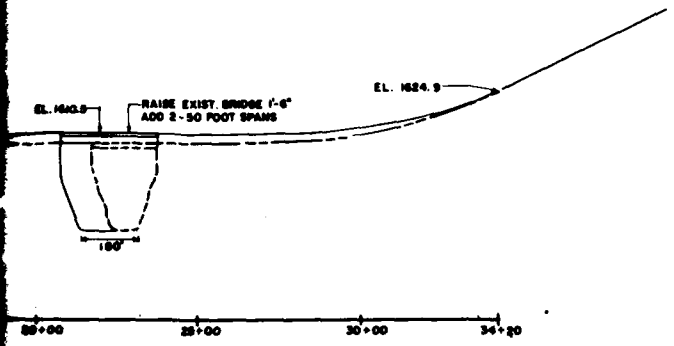
SCALE 0 5' 10'

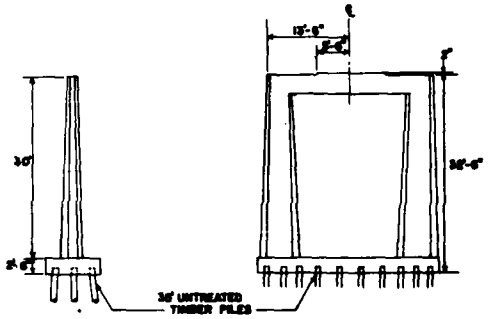




TYPICAL BRIDGE CROSS SECTION

SCALE: 0 4' 8'

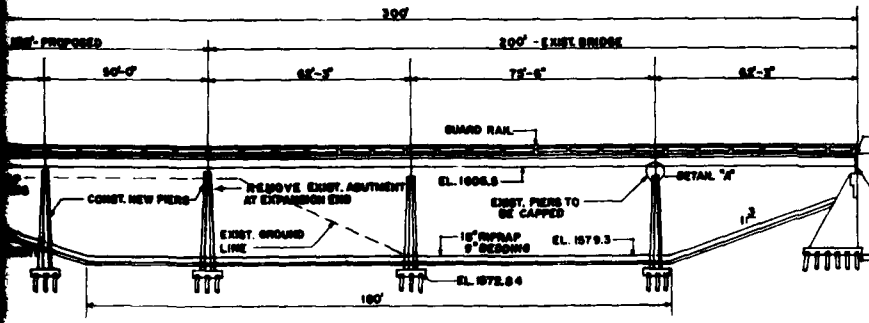




END VIEW

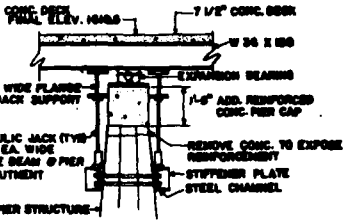
ELEVATION NEW PIER

SCALE: 0 4' 8'



PROFILE OF RAISED BRIDGE

SCALE 0 20' 40'



DETAIL "A"
BRIDGE RAISE STATE HWY. 5
N.T.S.

SYMBOL	DESCRIPTION	DATE	APPROVED

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

DESIGNED BY:	MLC
DRAWN BY:	MLC
TRACED BY:	GRS MLC
SUBMITTED BY:	
RECOMMENDED:	
APPROVED:	

DESIGN MEMORANDUM NO. 3 GENERAL

FLOOD CONTROL — LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
HIGHWAY 5
RELOCATION

DATE: JUNE 1963

SCALE: AS SHOWN

DRAWING NUMBER: RI-R-5/724

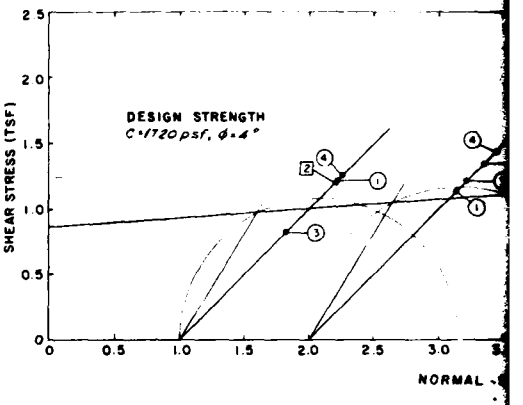
SHEET OF

SAFETY PAYS

PLATE B-25

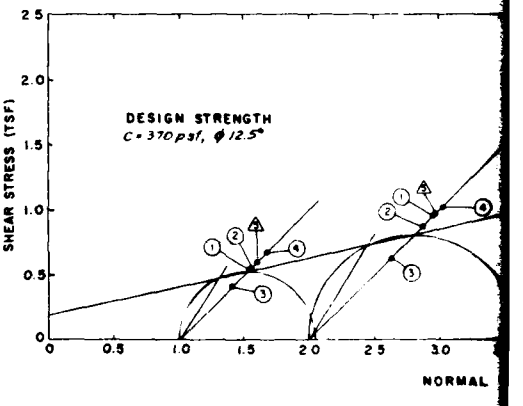
Q-TESTS

TEST NO	BORING NO	SAMPLE No	LIQUID LIMIT	PLASTIC LIMIT	OPTIMUM M C (%)	SAMPLE M C (%)
①	74-46TP	1	44	14	17.9	17.3
②	74-46TP	5	27	12	17.9	17.0
③	74-47TP	1	35	13	13.9	14.1
④	74-47TP	6	34	12	16.3	15.9



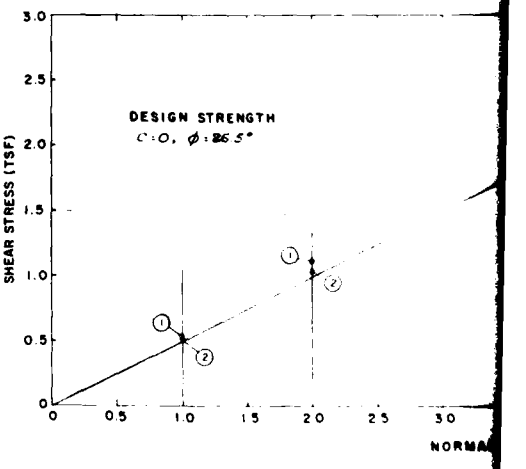
R-TESTS

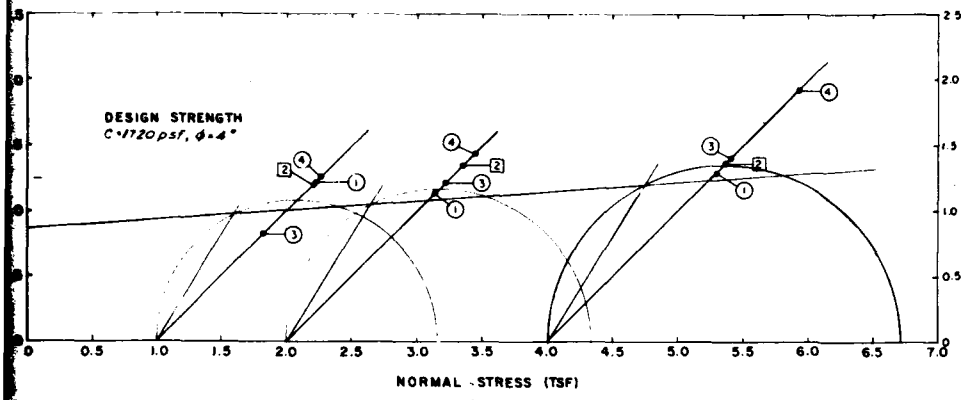
TEST No.	BORING No.	SAMPLE No.	LIQUID LIMIT	PLASTIC LIMIT	OPTIMUM M.C (%)	SAMPLE M.C. (%)
①	74-46TP	1	44	14	17.9	17.9
②	74-46TP	5	27	12	17.9	17.7
③	74-47TP	1	35	13	13.9	13.9
④	74-47TP	6	34	12	16.3	16.3
△	74-47TP	6	34	12	16.3	18.2

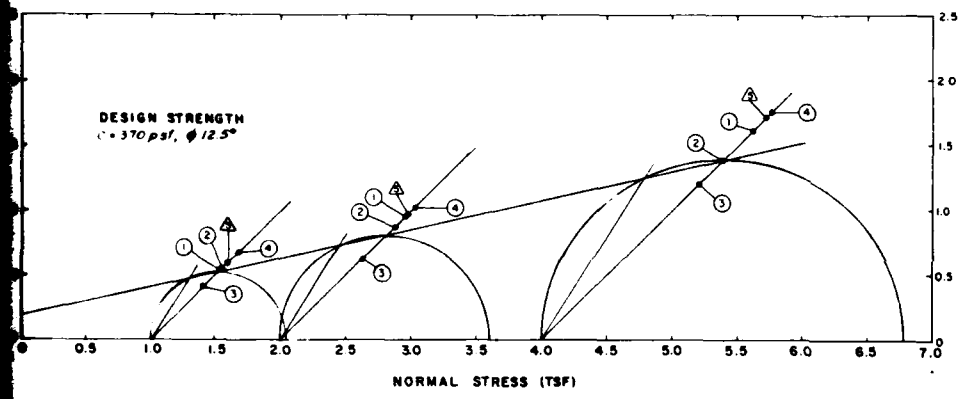


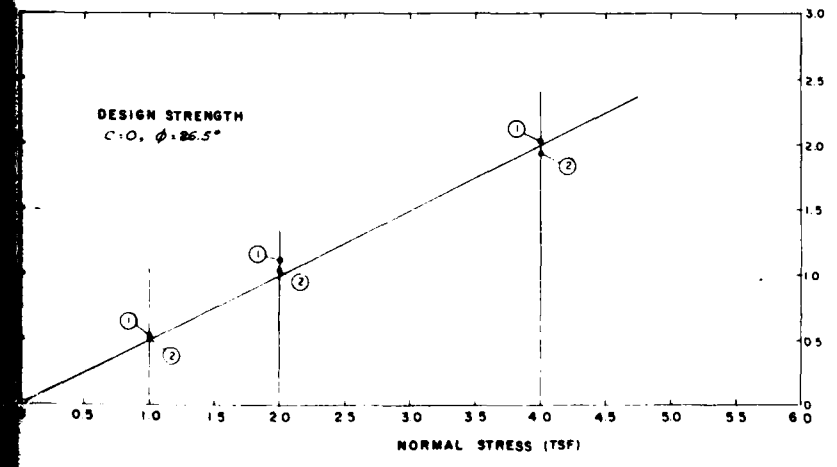
S-TESTS

TEST NO	BORING NO	SAMPLE No.	LIQUID LIMIT	PLASTIC LIMIT	OPTIMUM M.C (%)	SAMPLE M.C (%)
①	74-46TP	1	44	14	17.9	18.1
②	74-46TP	5	27	12	17.9	17.5









LEGEND

① - TESTS WERE RUN AT APPROXIMATELY OPTIMUM MOISTURE CONTENT.

② - TEST WERE RUN AT ABOUT 1% BELOW OPTIMUM MOISTURE CONTENT.

△ - TESTS WERE RUN AT ABOUT 2% ABOVE OPTIMUM MOISTURE CONTENT.

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
ST PAUL, MINNESOTA

DESIGNED BY M B
DRAWN BY J.M.J
CHECKED BY L.D.
SUBMITTED BY
APPROVED:

DESIGN MEMORANDUM NO 5 GENERAL
FLOOD CONTROL
LAKE DARLING DAM - SOURIS RIVER, NORTH DAKOTA

STATE HIGHWAY NO.5
REMOLDED STRENGTHS
GLACIAL TILL FROM RIGHT ABUTMENT

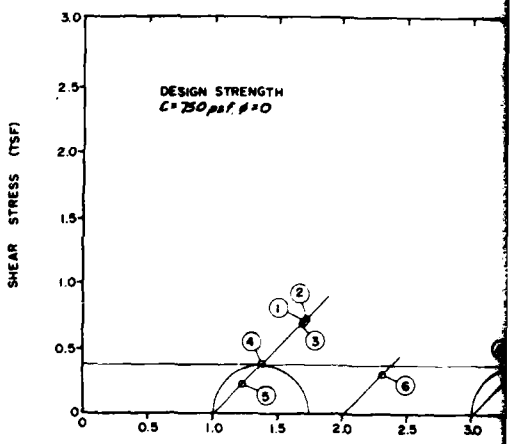
DATE
JUNE 1983

SCALE AS SHOWN
DRAWING NUMBER
RI-R-5/725
SHEET OF

PLATE B-26

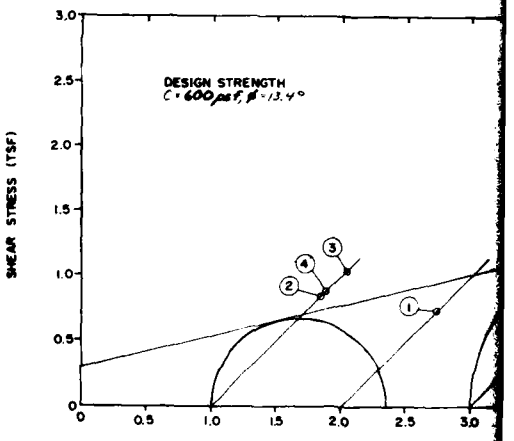
Q-TESTS

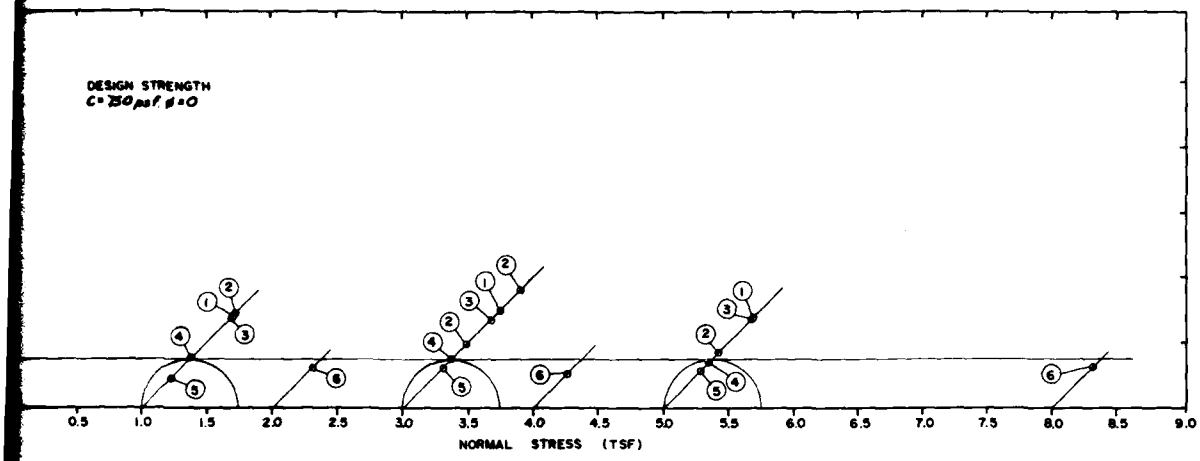
TEST NO.	BORING NO.	SAMPLE NO.	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	AVERAGE VOID RATIO	INITIAL SATURATION (%)
1	74-50N	4	32.5	57	21.0	0.930	96.0
2	74-50N	7	26.1	40	16.0	0.710	99.2
3	74-50N	11	28.9	45	20.0	0.800	97.3
4	74-50N	15	27.3	28	20.0	0.743	99.3
5	74-50N	18	32.8	45	18.0	0.877	100.0
6	64-10N	4	30.5	35	18.5	0.863	96.0

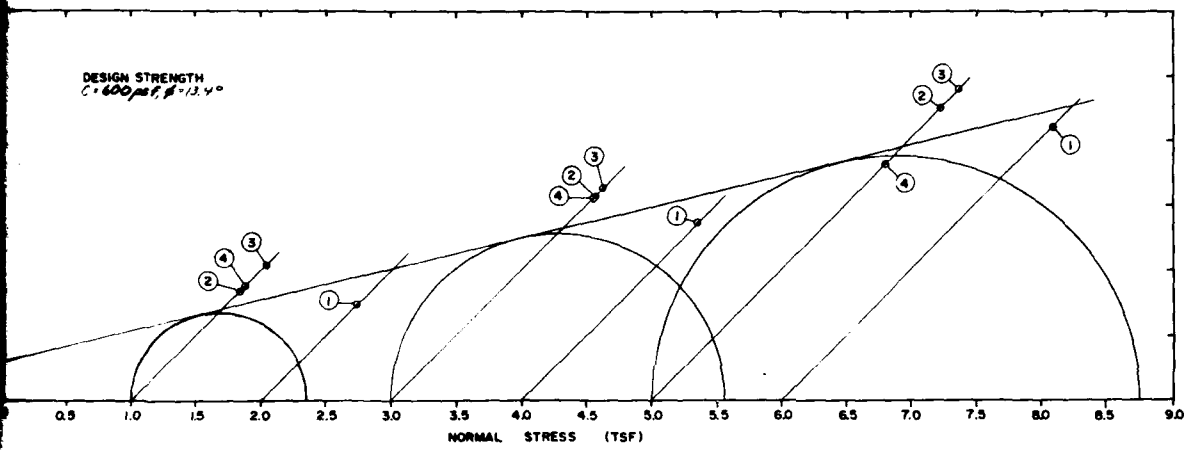


R-TESTS

TEST NO.	BORING NO.	SAMPLE NO.	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	AVERAGE VOID RATIO	INITIAL SATURATION (%)
1	74-50N	7	29.3	40	16	0.823	96.0
2	74-50N	11	31.9	45	20	0.870	98.7
3	74-50N	15	26.7	28	20	0.717	100.0
4	74-50N	18	28.8	45	18	0.783	98.7







SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
ST PAUL, MINNESOTA

DESIGNED BY: M B
DRAWN BY: D A E
TRACED BY:
CHECKED BY: L D
SUBMITTED BY:
APPROVED:

DESIGN MEMORANDUM NO. 3 GENERAL

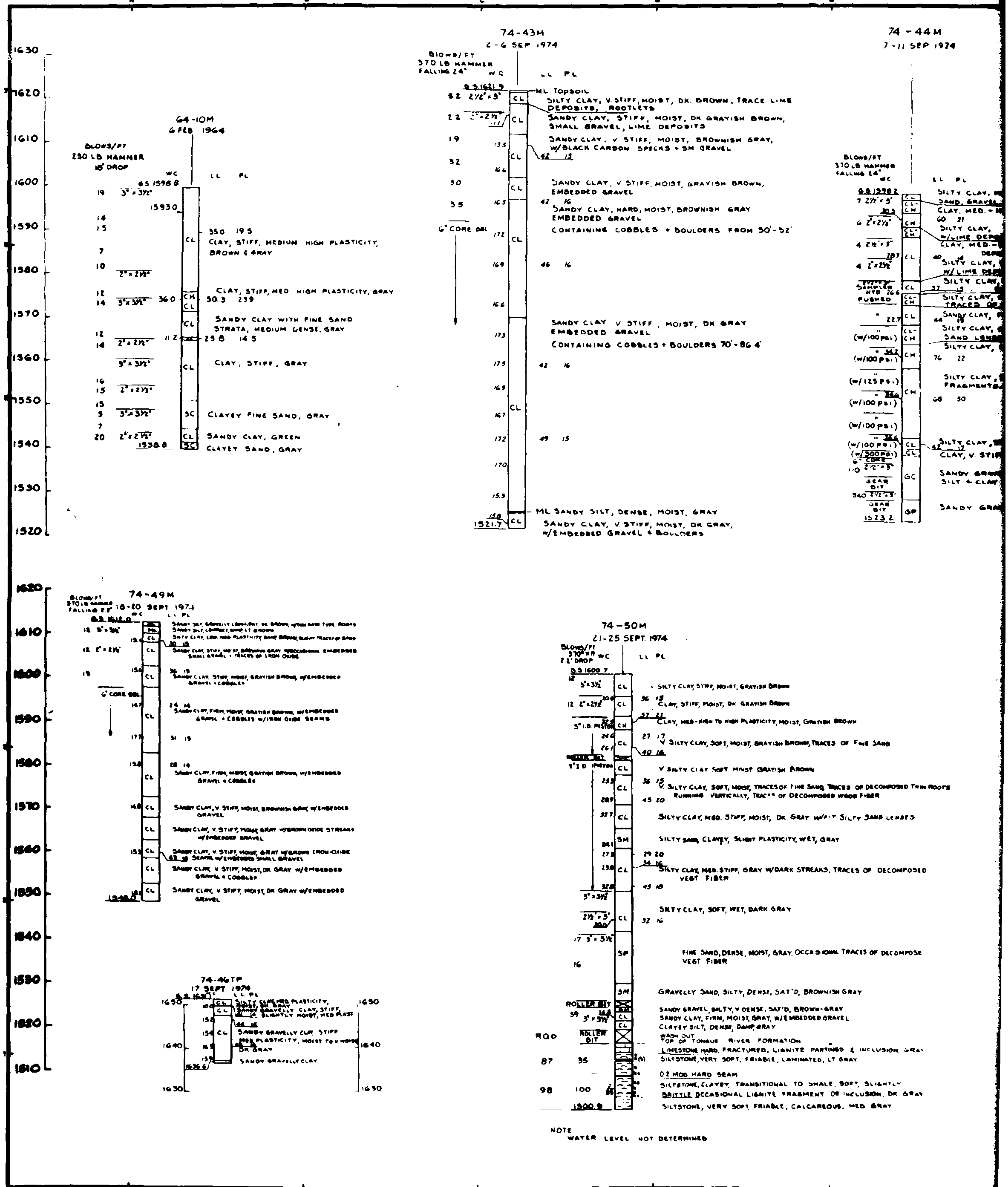
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
STATE HIGHWAY NO. 5
FOUNDATION STRENGTHS

DATE: JUNE 1983
SCALE: AS SHOWN
DRAWING NUMBER: RI-R-5/726
SHEET OF

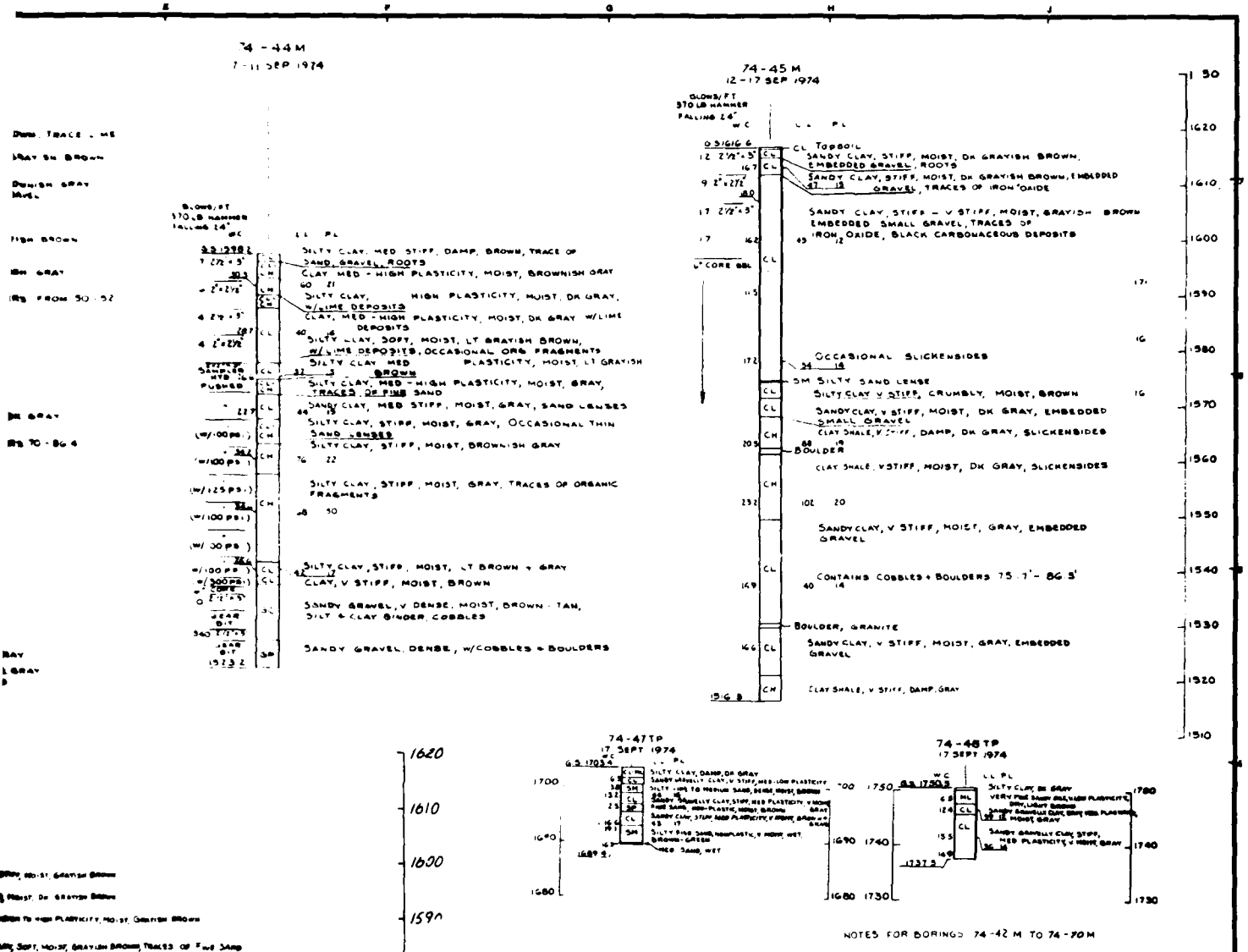
SAFETY PAYS

PLATE NO. B-27

1 2



74-43M
2-6 SEP 1974
BLOWS/FT
370 LB HAMMER
FALLING 24"
WC
LL PL
ML Topsoil
SILTY CLAY, V. STIFF, MOIST, DK. BROWN, TRACE LIME DEPOSITS, ROOTLETS
SANDY CLAY, STIFF, MOIST, DK GRAYISH BROWN, SMALL GRAVEL, LIME DEPOSITS
SANDY CLAY, V. STIFF, MOIST, BROWNISH GRAY, W/BLACK CARBON SPECKS + SM GRAVEL
SANDY CLAY, V STIFF, MOIST, GRAYISH BROWN, EMBEDDED GRAVEL
SANDY CLAY, HARD, MOIST, BROWNISH GRAY EMBEDDED GRAVEL
CONTAINING COBBLES + BOULDERS FROM 50'-52'
6" CORE BBL
SANDY CLAY V STIFF, MOIST, DK GRAY EMBEDDED GRAVEL
CONTAINING COBBLES + BOULDERS 70'-86.4'
ML SANDY SILT, DENSE, MOIST, GRAY
SANDY CLAY, V STIFF, MOIST, DK GRAY, W/EMBEDDED GRAVEL + BOULDERS
1521.7
64-10M
6 FEB 1964
BLOWS/FT
250 LB HAMMER
18" DROP
GS 1598.8
1593.0
CLAY, STIFF, MEDIUM HIGH PLASTICITY, BROWN & GRAY
CLAY, STIFF, MED HIGH PLASTICITY, GRAY
SANDY CLAY WITH FINE SAND STRATA, MEDIUM DENSE, GRAY
CLAY, STIFF, GRAY
CLAYEY FINE SAND, GRAY
SANDY CLAY, GREEN
CLAYEY SAND, GRAY
1538.8
74-44M
7-11 SEP 1974
BLOWS/FT
370 LB HAMMER
FALLING 24"
74-49M
18-20 SEPT 1974
74-50M
21-25 SEPT 1974
SILTY CLAY, STIFF, MOIST, GRAYISH BROWN
CLAY, STIFF, MOIST, DK GRAYISH BROWN
CLAY, MED-HIGH TO HIGH PLASTICITY, MOIST, GRAYISH BROWN
V SILTY CLAY, SOFT, MOIST, GRAYISH BROWN, TRACES OF FINE SAND
SILTY CLAY, MED. STIFF, MOIST, DK. GRAY
SILTY CLAY, SOFT, WET, DARK GRAY
FINE SAND, DENSE, MOIST, GRAY
GRAVELLY SAND, SILTY, DENSE, SAT'D, BROWNISH GRAY
TOP OF TONGUE RIVER FORMATION
RQD
1500.9
74-46TP
17 SEPT 1974
NOTE
WATER LEVEL NOT DETERMINED



NOTES FOR BORINGS 74-42 M TO 74-50 M

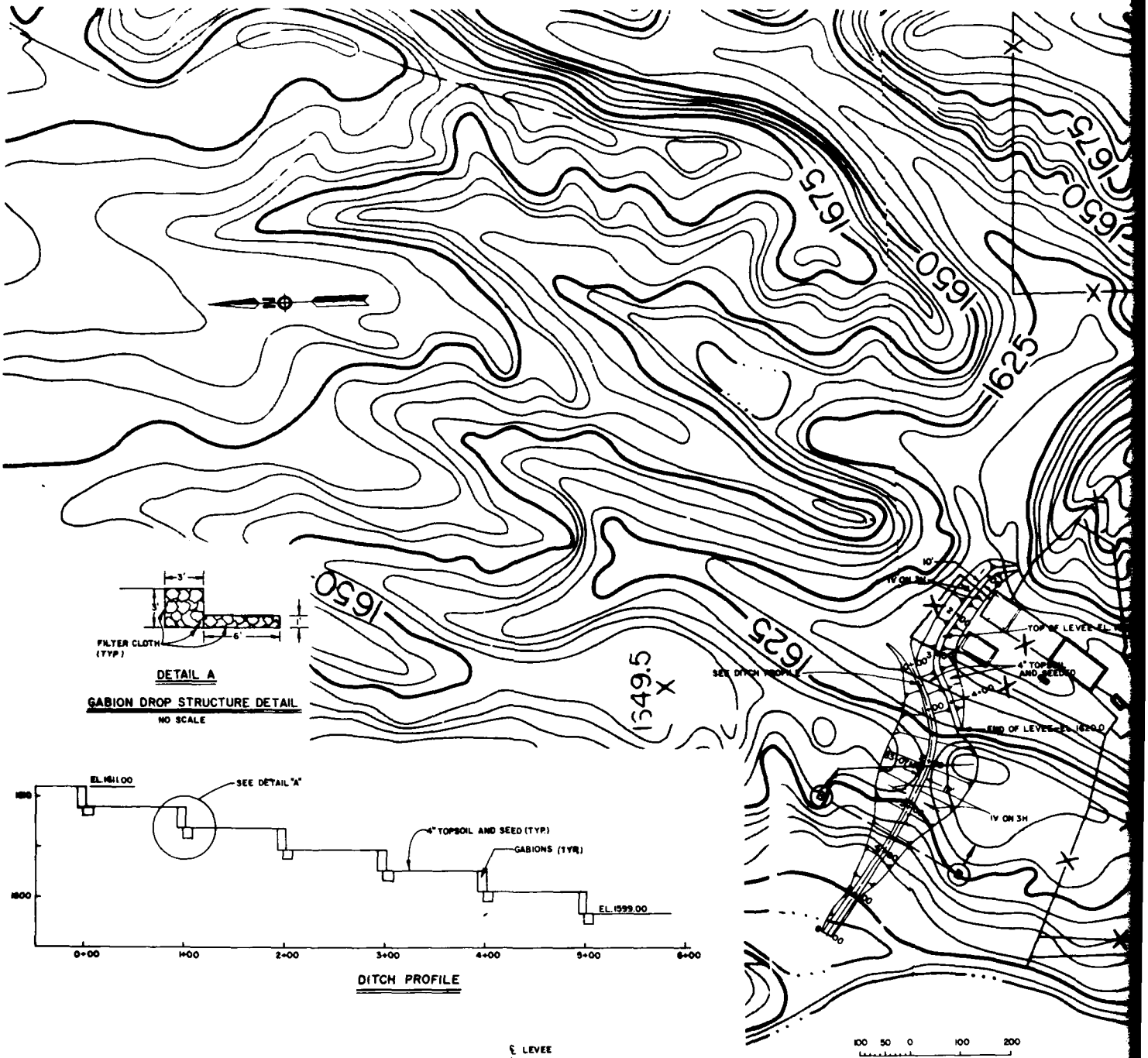
1. THE OVERBURDEN WAS DRILLED BY DRIVE SAMPLING, PUSHING SAMPLERS HYDRAULICALLY AND CORING. THE TYPES OF SAMPLERS USED, WEIGHTS OF HAMMERS AND LENGTHS OF DROP ARE SHOWN IN THE BLOW-COUNT COLUMN TO THE LEFT OF THE BORING STAFF. DRIVE SAMPLERS ARE IDENTIFIED BY INCHES OF INSIDE AND OUTSIDE DIAMETERS, SUCH AS 2"Ø x 2½".
2. EXCEPT WHERE NOTED, ALL BORINGS WERE STABILIZED WITH BENTONITE DRILLING MUD WITH ONLY A SHORT PIECE OF CASING SET AT THE GROUND SURFACE TO CONTROL THE DRILLING-MUD RETURN.
3. UNLESS NOTED OTHERWISE, CORING WAS ACCOMPLISHED WITH A 4 x 5½-INCH (4-INCH CORE) DOUBLE-TUBE CORE BARREL USING A BOTTOM-DISCHARGE DIAMOND BIT.
4. ALL HOLES WERE BACKFILLED WITH NEAT CEMENT.

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

DESIGNED BY: LHB	DESIGN MEMORANDUM NO. 3 GENERAL
DRAWN BY: J.M.J.	FLOOD CONTROL - LAKE DARLING SOURIS RIVER, NORTH DAKOTA
SUBMITTED BY: LHB	STATE HIGHWAY NO 5
APPROVED: Peter A. Tinkham	BORINGS 64-10, 74-43M, 74-44M, 74-45M 74-49M AND 74-50M
	DATE: JUNE 1983
	DRAWING NUMBER: RI-R-5/727
	SHEET OF

PLATE NO. B-28

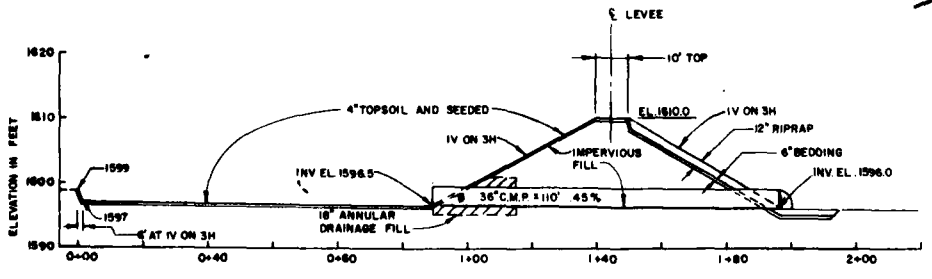


DETAIL A

GABION DROP STRUCTURE DETAIL

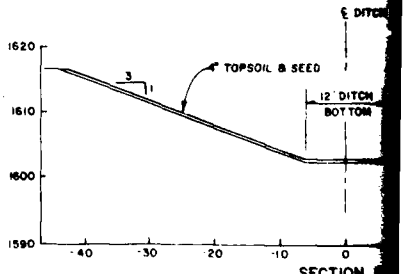
NO SCALE

DITCH PROFILE

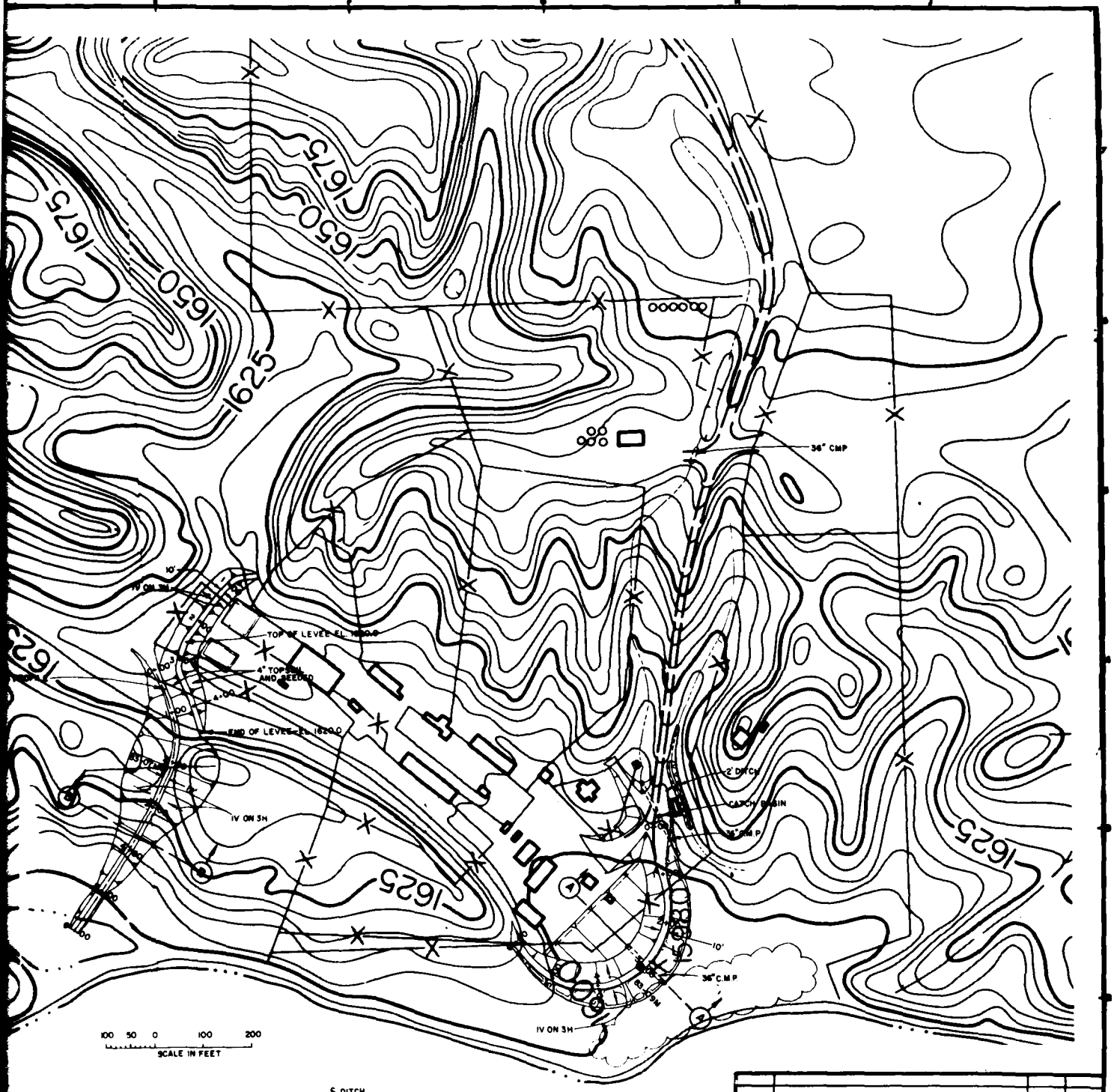


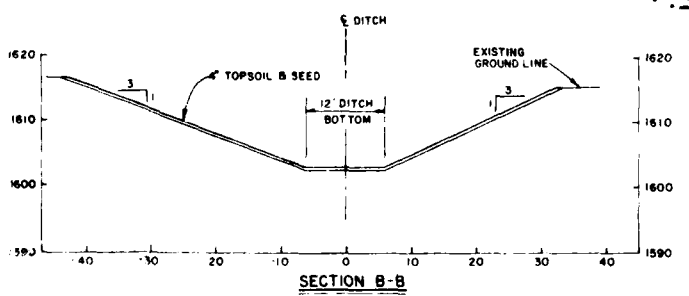
SECTION A-A

STORAGE AREA



SECTION





SECTION B-B

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

DESIGN MEMORANDUM NO 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
PLAN
ECKERT RANCH

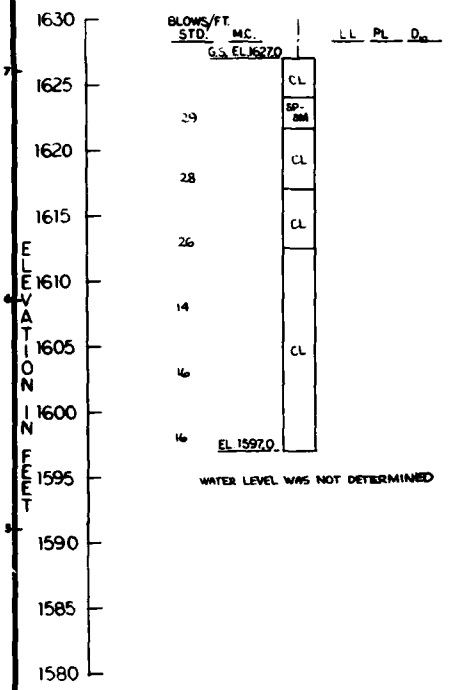
DESIGNED BY: WJM & L H B & J J F
DRAWN BY: J M J
TRACED BY: W J M & M M B & A M K
SUBMITTED BY:
APPROVED:
DATE: JUNE 1983

DRAWING NUMBER
RI-R-5/728
SHEET OF

SAFETY PAYS

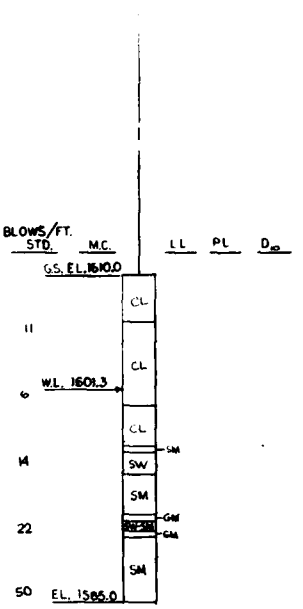
PLATE B-29

83-7M
09 FEBRUARY 1983



WATER LEVEL WAS NOT DETERMINED

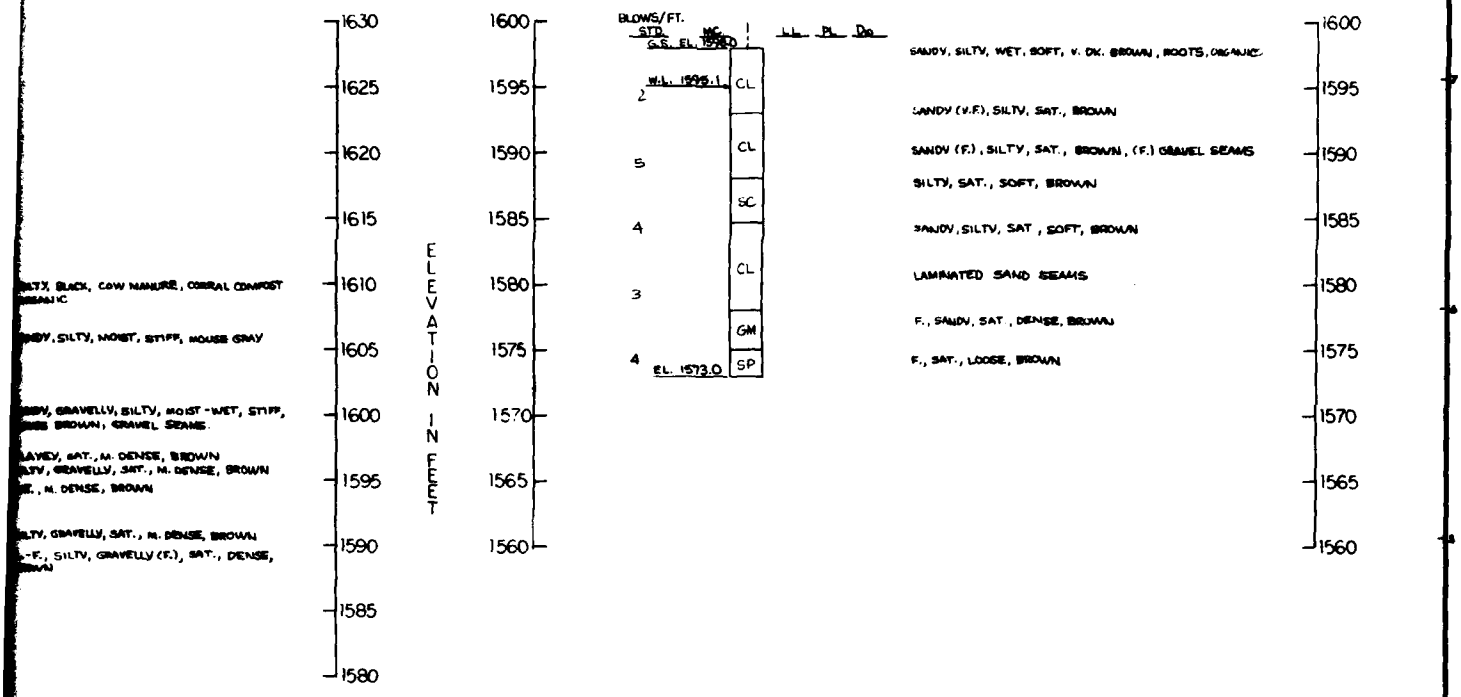
83-8M
09 FEBRUARY 1983



ELEVATION IN FEET

1630
1625
1620
1615
1610
1605
1600
1595
1590
1585
1580

83-9M
10 FEBRUARY 1983



DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

DESIGN MEMORANDUM NO 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
ECKERT RANCH
BORINGS 83-7M THRU 83-9M

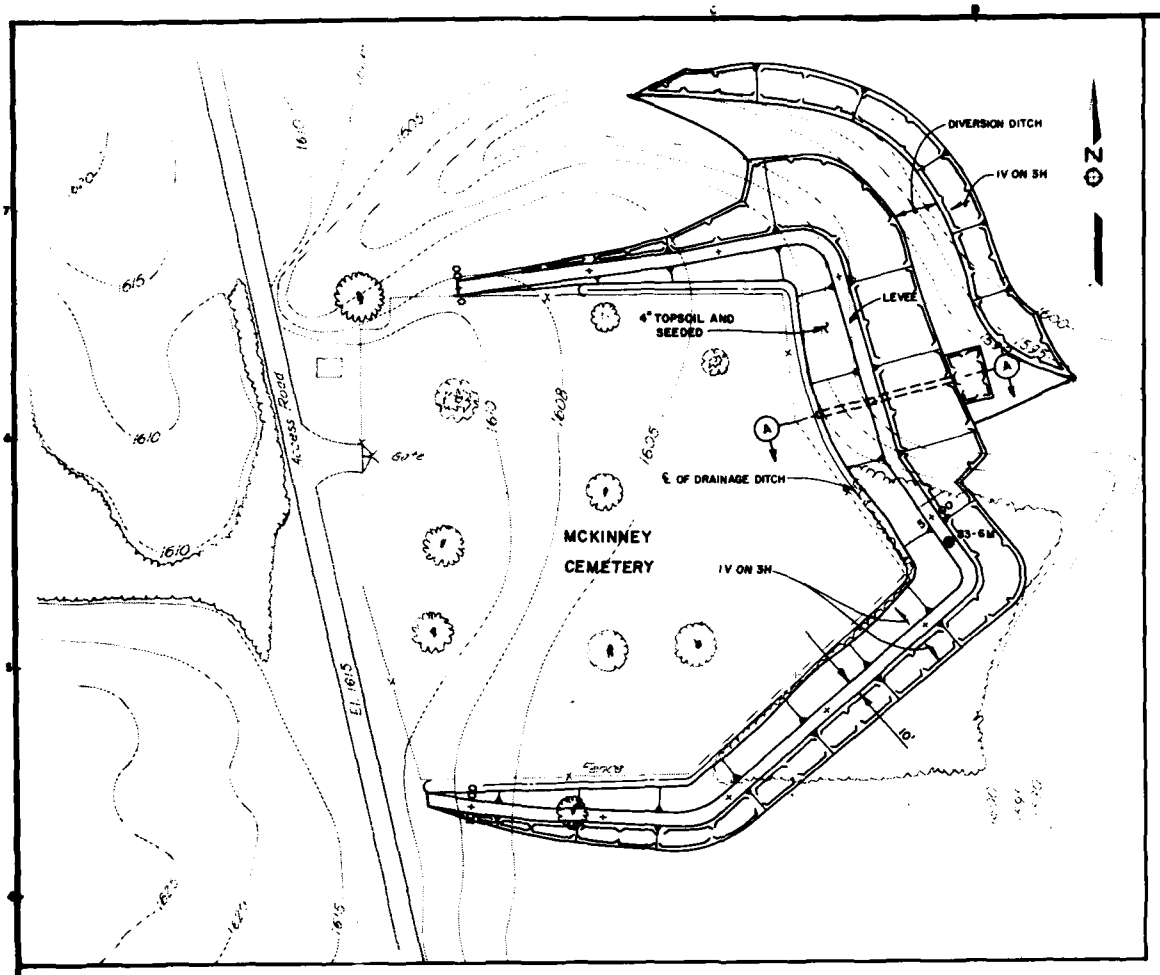
DESIGNED BY: L.H.B.
DRAWN BY: L.H.B.
TRACED BY: M.M.B.
SUBMITTED BY:
APPROVED:
DATE: JUNE 1983

DRAWING NUMBER
RI-R-5/729
SHEET OF

SAFETY PAYS

PLATE NO. B-30

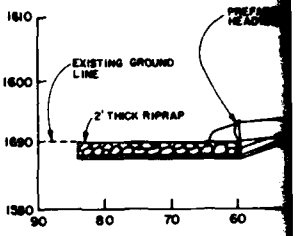
1 2

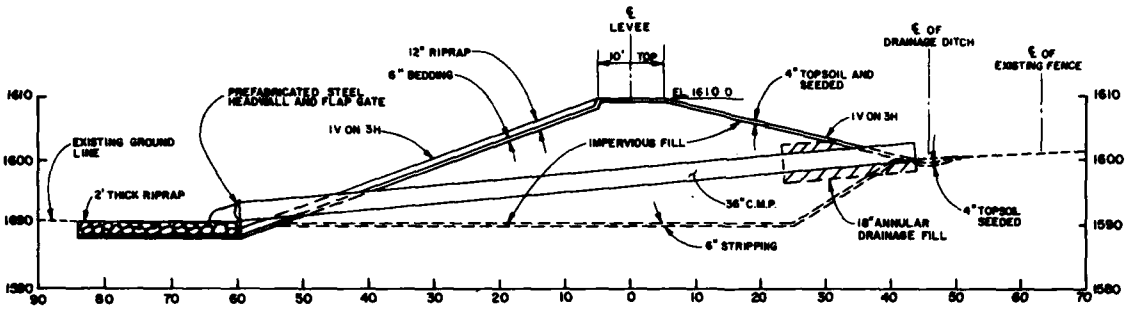


PLAN

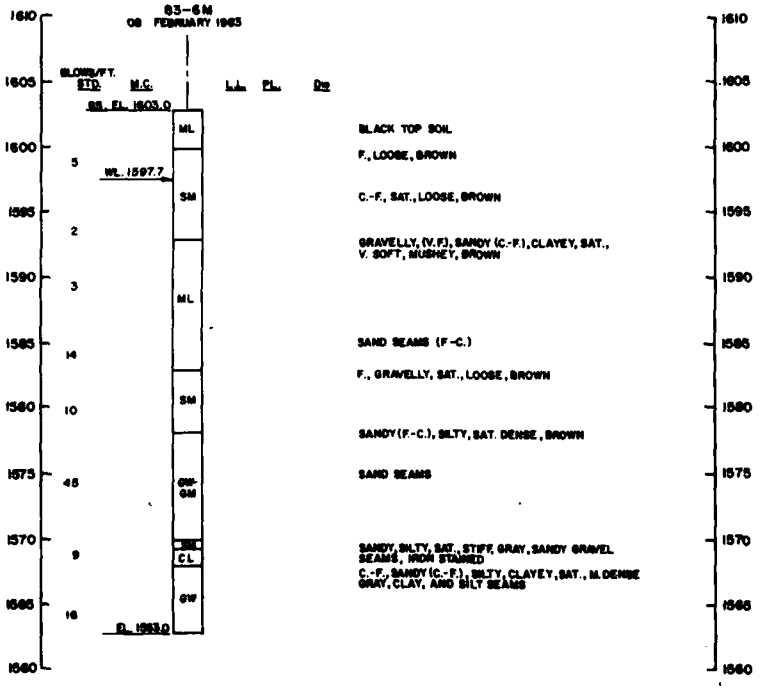
0 50 100

SCALE IN FEET





SECTION A-A
STATION 4+00



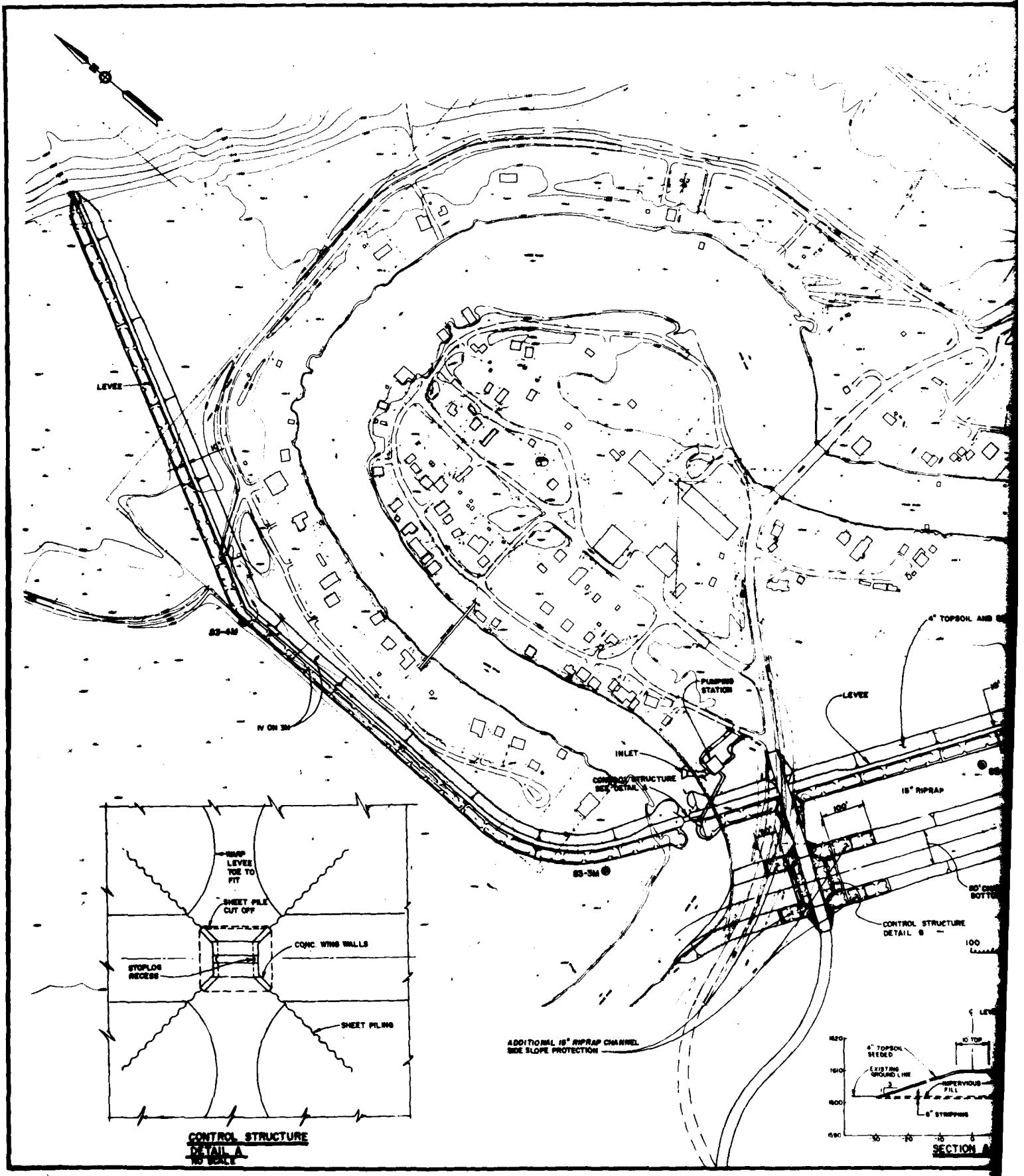
SYMBOL	DESCRIPTION	DATE	APPROVAL

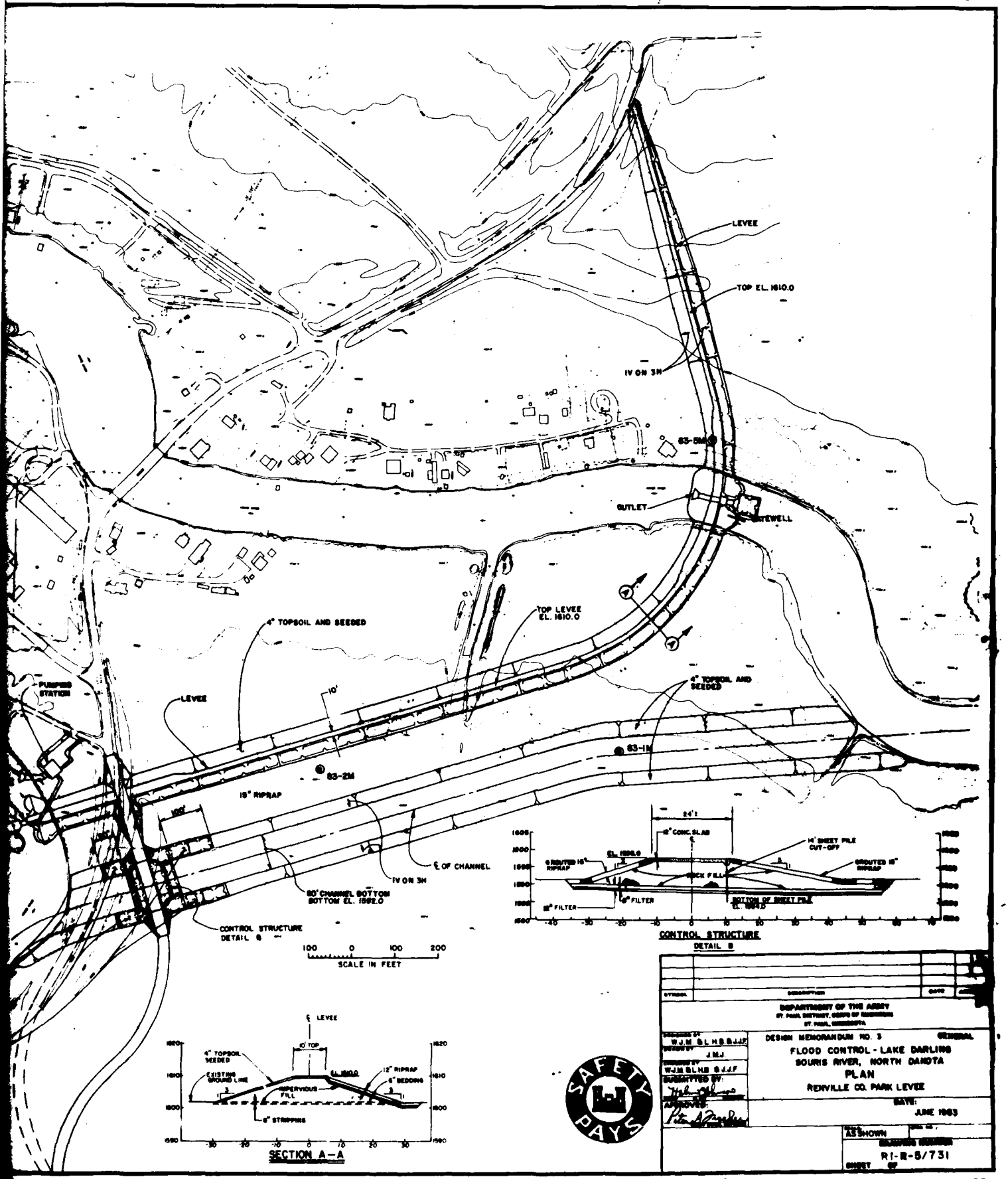
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

DESIGNED BY: L.N.B.	DESIGN MEMORANDUM NO. 3 GENERAL
DRAWN BY: CRE	FLOOD CONTROL - LAKE DARLING
TRACED BY: M.M.S.	SOURIS RIVER, NORTH DAKOTA
SUBMITTED BY:	PLAN AND SECTIONS
APPROVED:	MCKINNEY CEMETERY LEVEE
	DATE: JUNE 1983
SCALE: AS SHOWN	GRID NO.
	DRAWING NUMBER: RI-R-5/730
SHEET OF	

PLATE NO. B-31

1 2


LEVEE
PUMPING STATION
INLET
CONTROL STRUCTURE SEE DETAIL B
18" RIPRAP
CONTROL STRUCTURE DETAIL B
ADDITIONAL 18" RIPRAP CHANNEL SIDE SLOPE PROTECTION
4" TOPSOIL SEEDED
EXISTING GROUND LINE
IMPERVIOUS FILL
6" STRIPPING
SECTION
SHEET PILE CUT OFF
CONC. WING WALLS
STOPLOG RECESS
SHEET PILING
CONTROL STRUCTURE
DETAIL A



SAFETY PAYS

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

DESIGNED BY	WJM BLHB BJJF
DRAWN BY	JMJ
TRACED BY	WJM BLHB BJJF
SUBMITTED BY:	
APPROVED:	

DESIGN MEMORANDUM NO. 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
PLAN
RENVILLE CO. PARK LEVEE

DATE: JUNE 1963

AS SHOWN

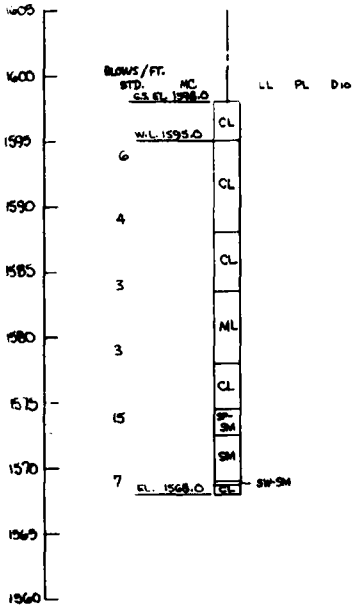
RI-B-5/731

SHEET 57

PLATE B-32

1 2

83-1M
02 FEBRUARY 1983



SILTY, PLASTIC, DK. GRAY

SILTY, SAT., M. STIFF, GRAY, IRON STAINED

F. SAND (<8%), SAT., SOFT, LT. GRAY WITH WHITE MOLLUSCOUS

SANDY, SILTY, SAT., M. STIFF, GRAY

OCCASIONAL SEAMS OF SANDY, CLAYEY, SILT, V. SOFT, (MH)

SANDY (V.V.F.), CLAYEY, SAT., SOFT, GRAY AND GREEN

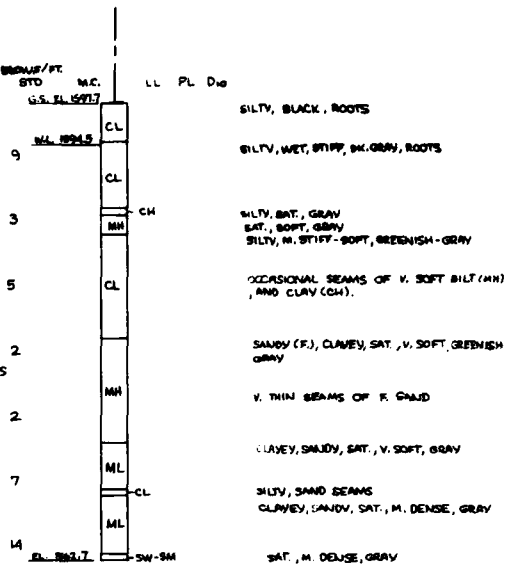
SILTY, SAT., M. STIFF, GRAY, M. STIFF, SILT SEAMS

F., SAT., M. DENSE, GREENISH GRAY

F., SAT., V. LOOSE, GREENISH GRAY, OCCASIONAL SILT SEAMS

SILTY, STIFF, GRAY

83-2M
03 FEBRUARY 1983



SILTY, BLACK, ROOTS

SILTY, WET, STIFF, DK. GRAY, ROOTS

SILTY, SAT., GRAY
SAT., SOFT, GRAY
SILTY, M. STIFF - SOFT, GREENISH - GRAY

OCCASIONAL SEAMS OF V. SOFT SILT (MH), AND CLAY (CH).

SANDY (F.), CLAYEY, SAT., V. SOFT, GREENISH GRAY

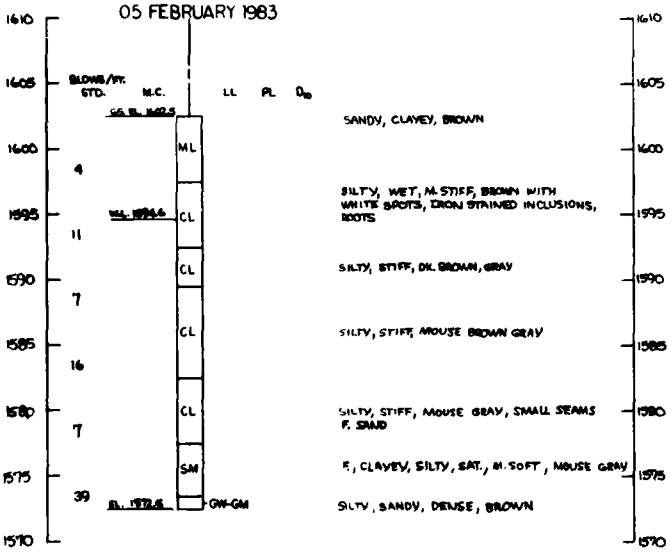
V. THIN SEAMS OF F. SAND

CLAYEY, SANDY, SAT., V. SOFT, GRAY

SILTY, SAND SEAMS
CLAYEY, SANDY, SAT., M. DENSE, GRAY

SAT., M. DENSE, GRAY

83-5M
05 FEBRUARY 1983



SANDY, CLAYEY, BROWN

SILTY, WET, M. STIFF, BROWN WITH WHITE SPOTS, IRON STAINED INCLUSIONS, ROOTS

SILTY, STIFF, DK. BROWN, GRAY

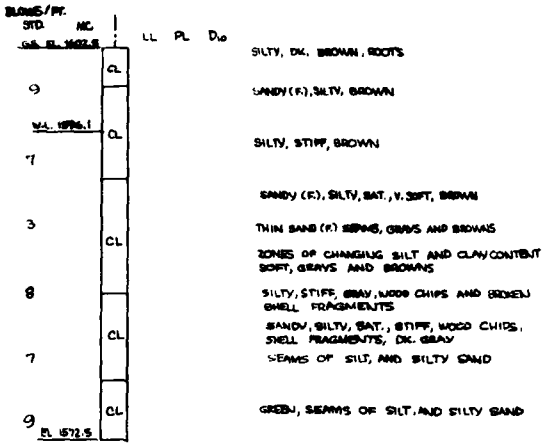
SILTY, STIFF, MOUSE BROWN GRAY

SILTY, STIFF, MOUSE GRAY, SMALL SEAMS F. SAND

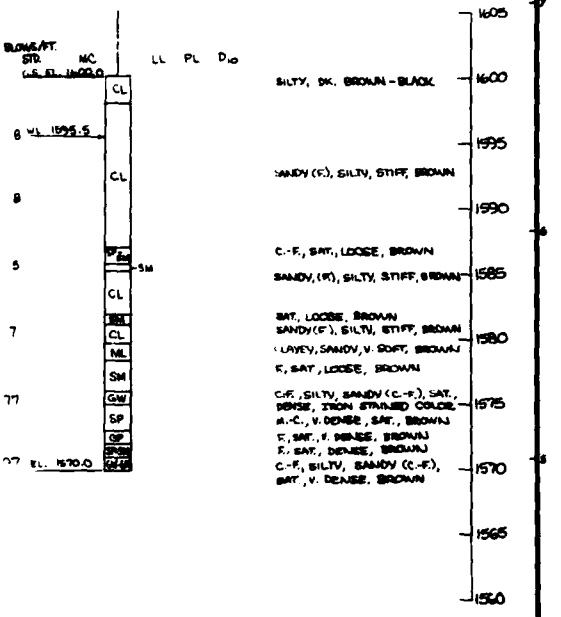
F., CLAYEY, SILTY, SAT., M. SOFT, MOUSE GRAY

SILTY, SANDY, DENSE, BROWN

83-3M
04 FEBRUARY 1983



83-4M
04 FEBRUARY 1983



SYMBOL	DESCRIPTION		DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

DESIGNED BY: L.H.B.
DRAWN BY: MMB
SUBMITTED BY:

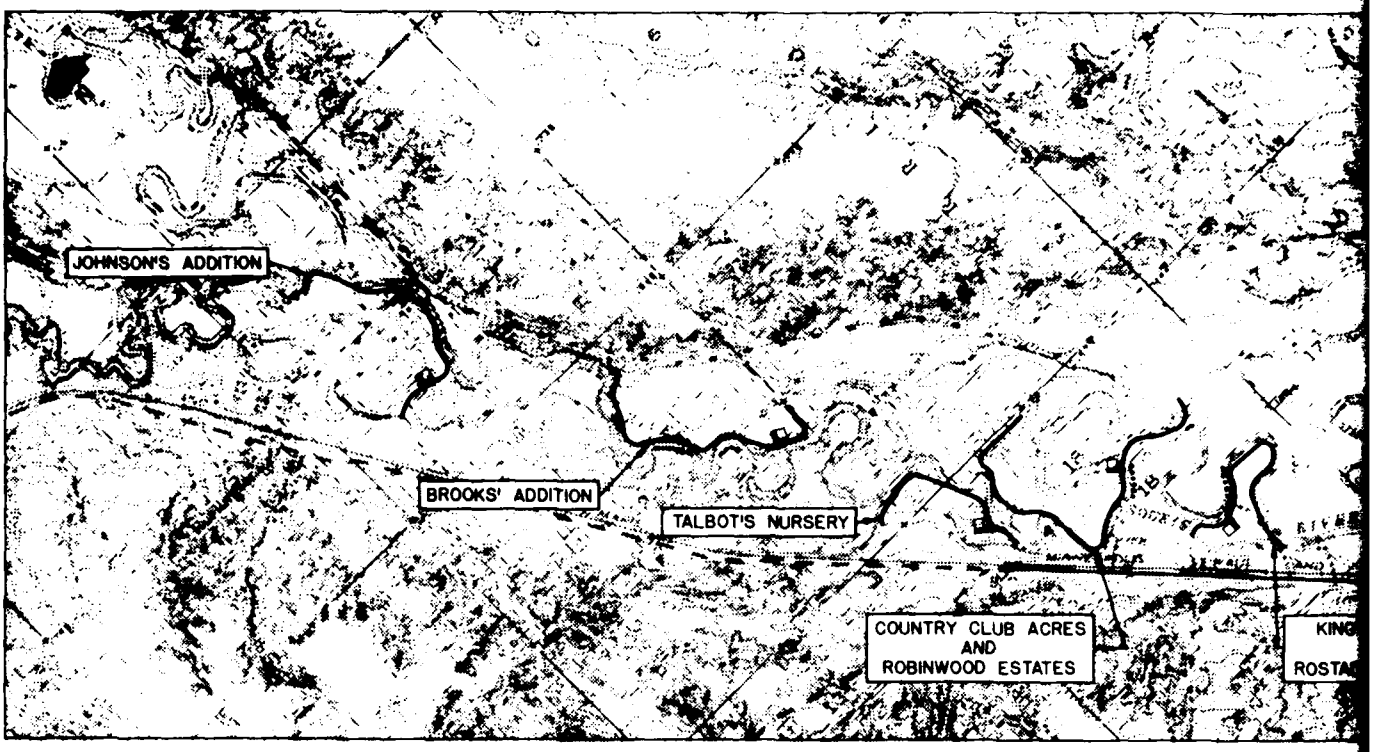
DESIGN MEMORANDUM NO 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
RENVILLE CO. PARK LEVEE
BORINGS 83-1M THRU 83-5M

APPROVED:
DATE: JUNE 1983

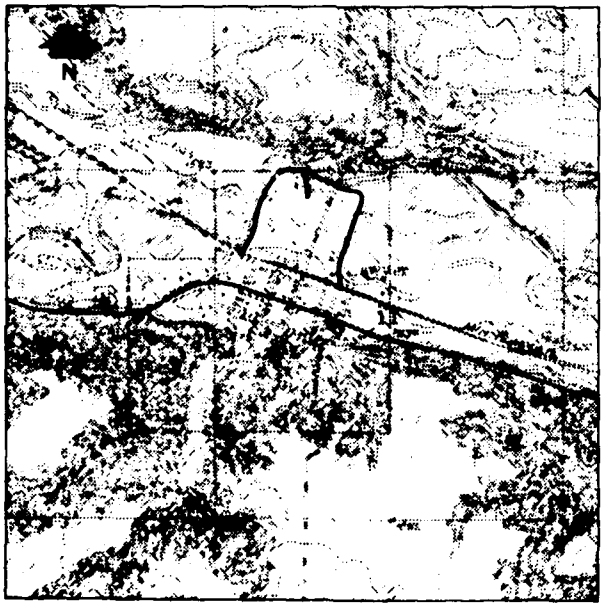
SCALE
SPEC. NO.

DRAWING NUMBER
RI-R-5/732
SHEET OF

PLATE NO. B-33



SOURIS RIVER REACH F – BETWEEN BURLINGTON A



SOURIS RIVER REACH AT SAWYER

LEGEND

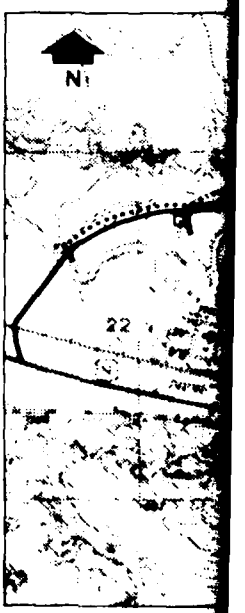
LEVEE ALIGNMENT

CHANNEL MODIFICATION

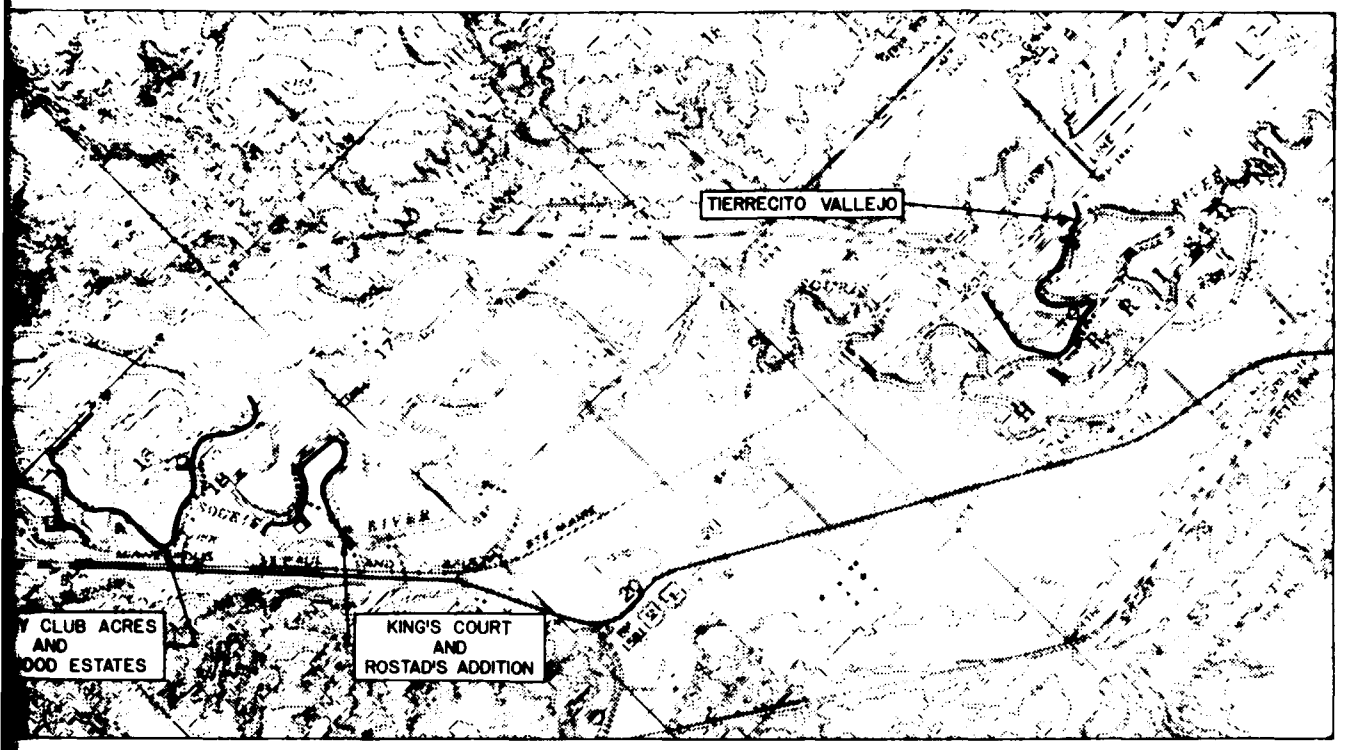
PUMPING STATION SITE

GRAVITY OUTLET

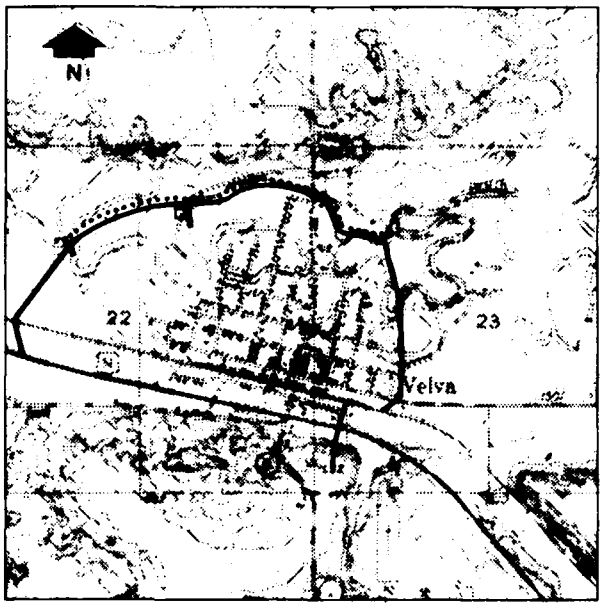
SCALE 0 1000 2000 3000 4000 FEET



SOURIS



R REACH F – BETWEEN BURLINGTON AND MINOT.



4000 FEET

SOURIS RIVER REACH AT VELVA

SAFETY PAYS

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
ST PAUL, MINNESOTA

DESIGN MEMORANDUM NO 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
GENERAL PLAN
MAJOR DOWNSTREAM WORKS

DRAWN BY: W.J.M L.H.B. J.J.F.
TRACED BY: J.M.J.
CHECKED BY: M.M.B. A.M.K. J.W.M.
SUBMITTED BY:
APPROVED:
DATE:

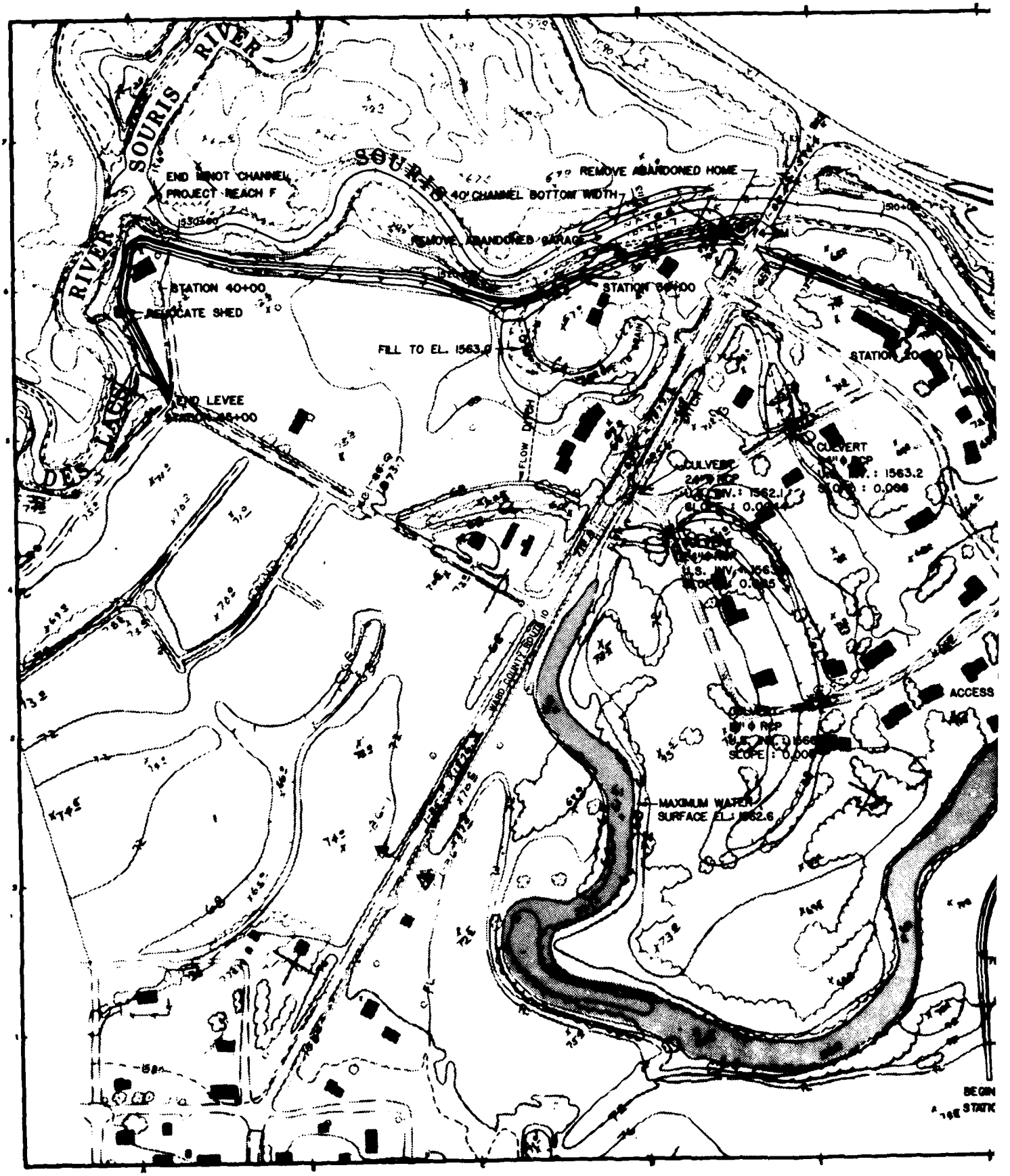
DRAWING NUMBER

SHEET OF

RI-R-8/733

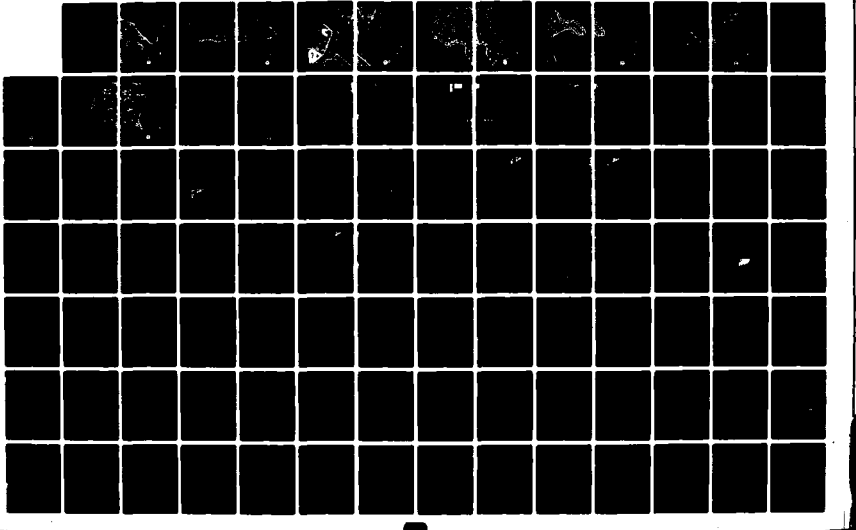
PLATE NO. B-34

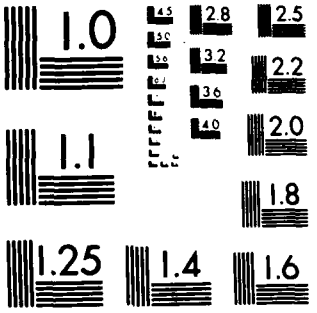
1 2

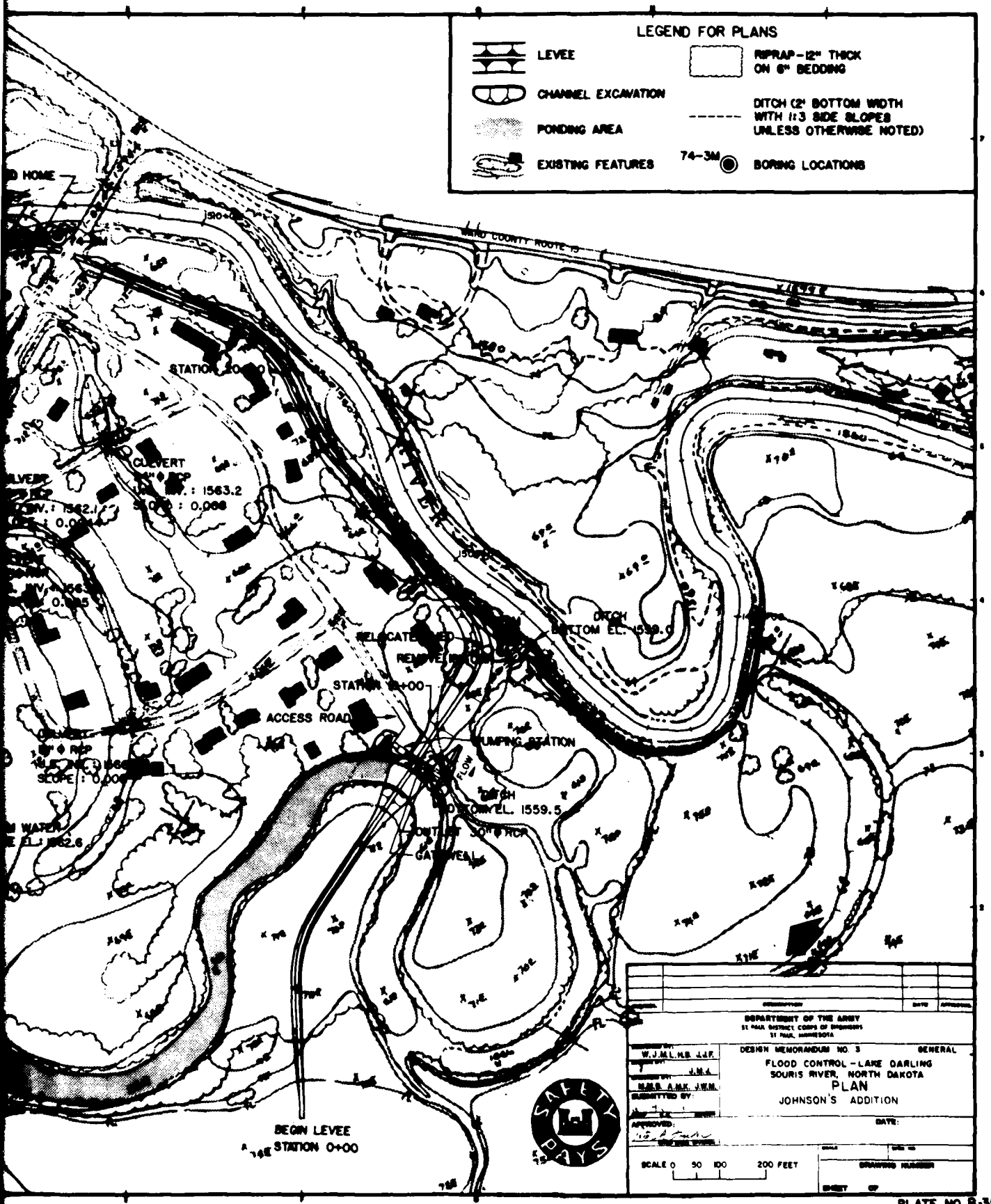

SOURIS RIVER
SOURIS RIVER
DES LACS
END MINOT CHANNEL PROJECT REACH F
40' CHANNEL BOTTOM WIDTH
REMOVE ABANDONED HOME
REMOVE ABANDONED GARAGE
STATION 40+00
RELOCATE SHED
STATION 50+00
FILL TO EL. 1563.0
END LEVEE
STATION 46+00
FLOW
CULVERT
CULVERT
24" RCP
INV.: 1562.1
SLOPE : 0.006
INV.: 1563.2
SLOPE : 0.006
MAIN COUNTY ROAD
ACCESS
MAXIMUM WATER SURFACE EL. 1562.6
BEGIN

AD-A136 229 LAKE DARLING FLOOD CONTROL PROJECT SOURIS RIVER NORTH DAKOTA GENERAL PROJ..(U) CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT JUN 83 2/3

UNCLASSIFIED F/G 8/7 NL



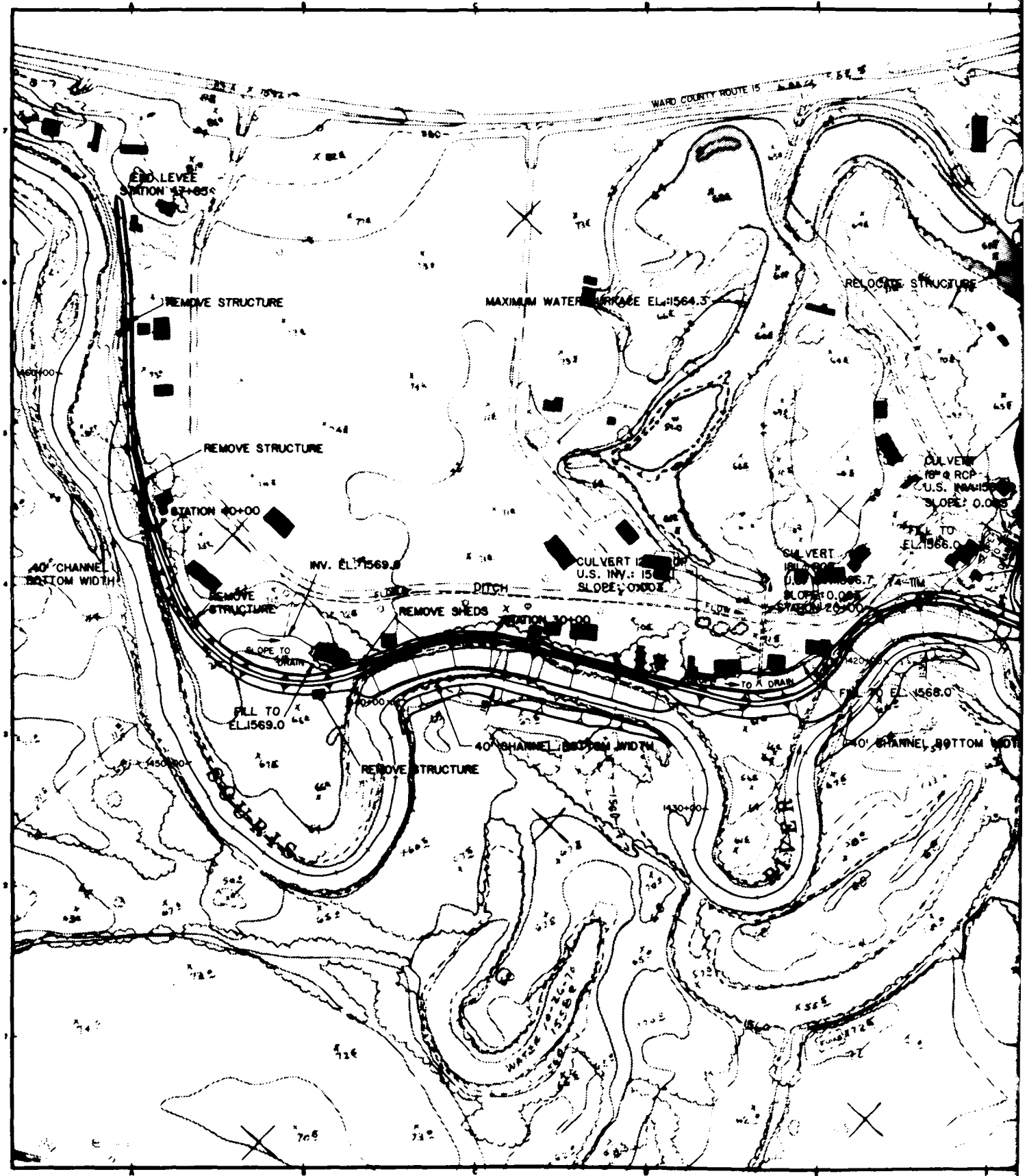


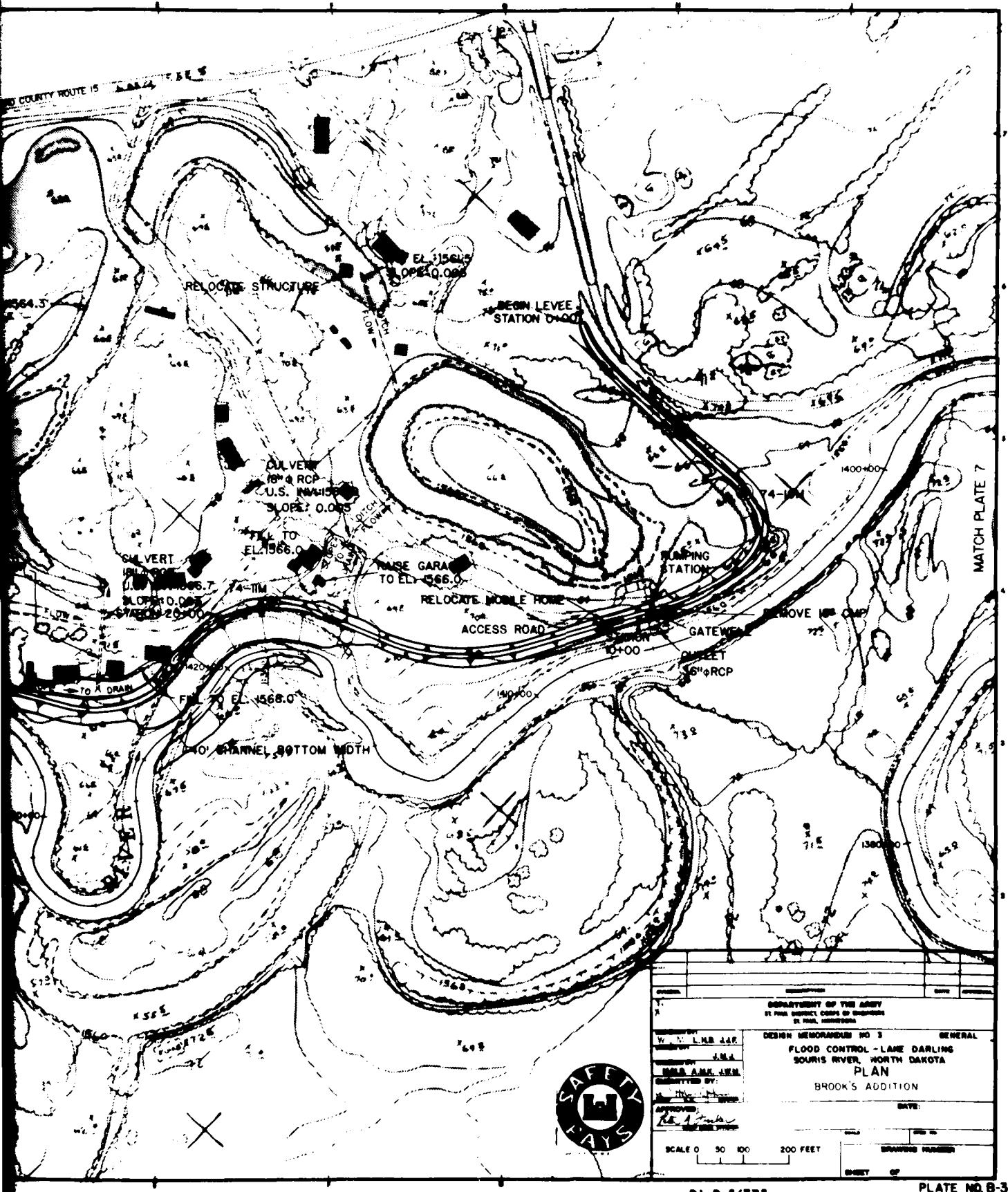


RI-R-8/734

PLATE NO. B-35

1 2

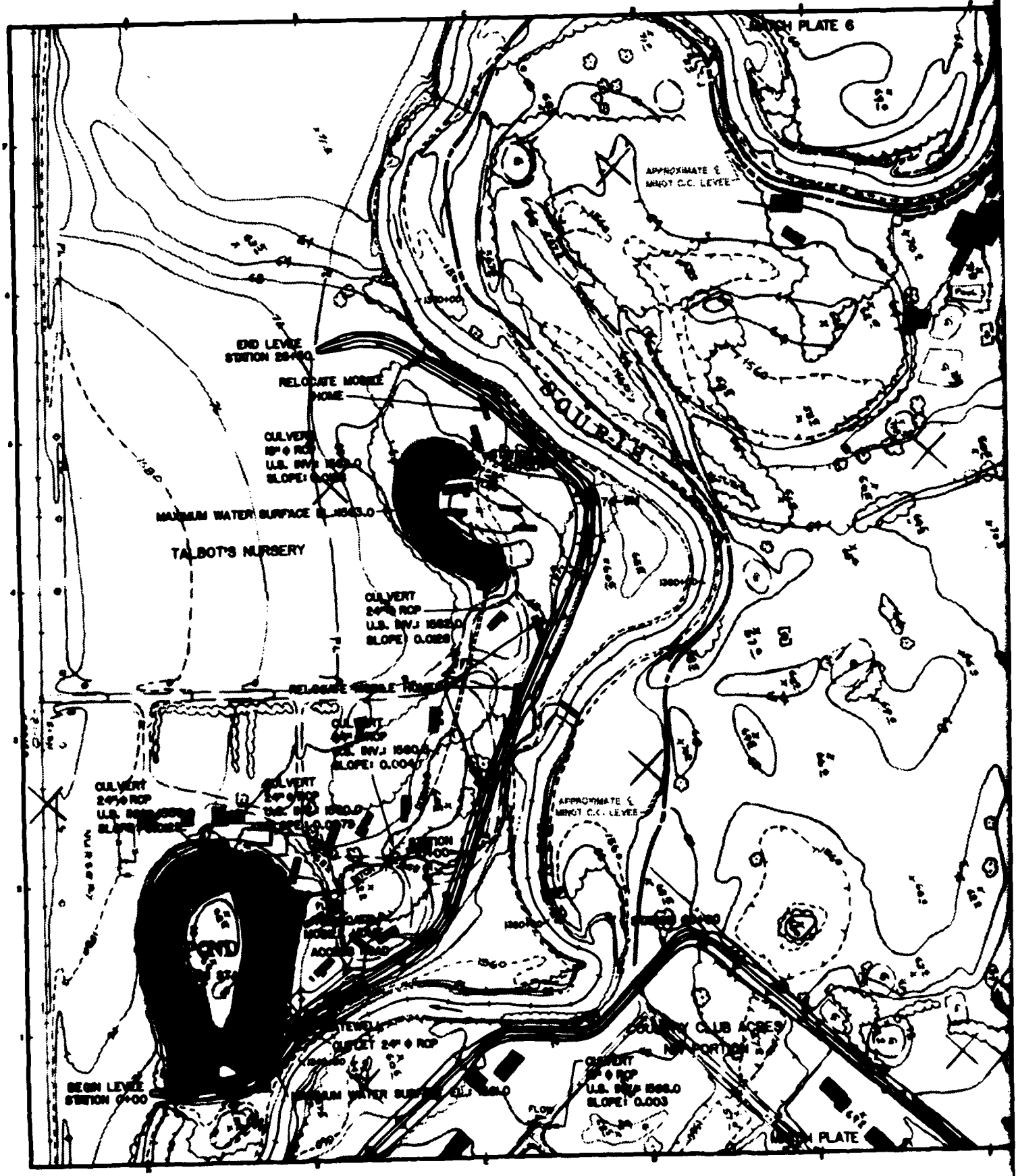

WARD COUNTY ROUTE 15
END LEVEE
REMOVE STRUCTURE
MAXIMUM WATER SURFACE EL. 1564.3
RELOCATE STRUCTURE
REMOVE STRUCTURE
STATION 40+00
INV. EL. 1569.8
CULVERT
U.S. INV.: 15
SLOPE: 0.00
DITCH
REMOVE STRUCTURE
REMOVE SHEDS
STATION 30+00
SLOPE TO DRAIN
FILL TO EL. 1569.0
40' CHANNEL BOTTOM WIDTH
REMOVE STRUCTURE
TO A DRAIN
FILL TO EL. 1568.0
40' CHANNEL BOTTOM WIDTH
SOURIS
RIVER



RI-R-8/735

PLATE NO. B-36

1 2

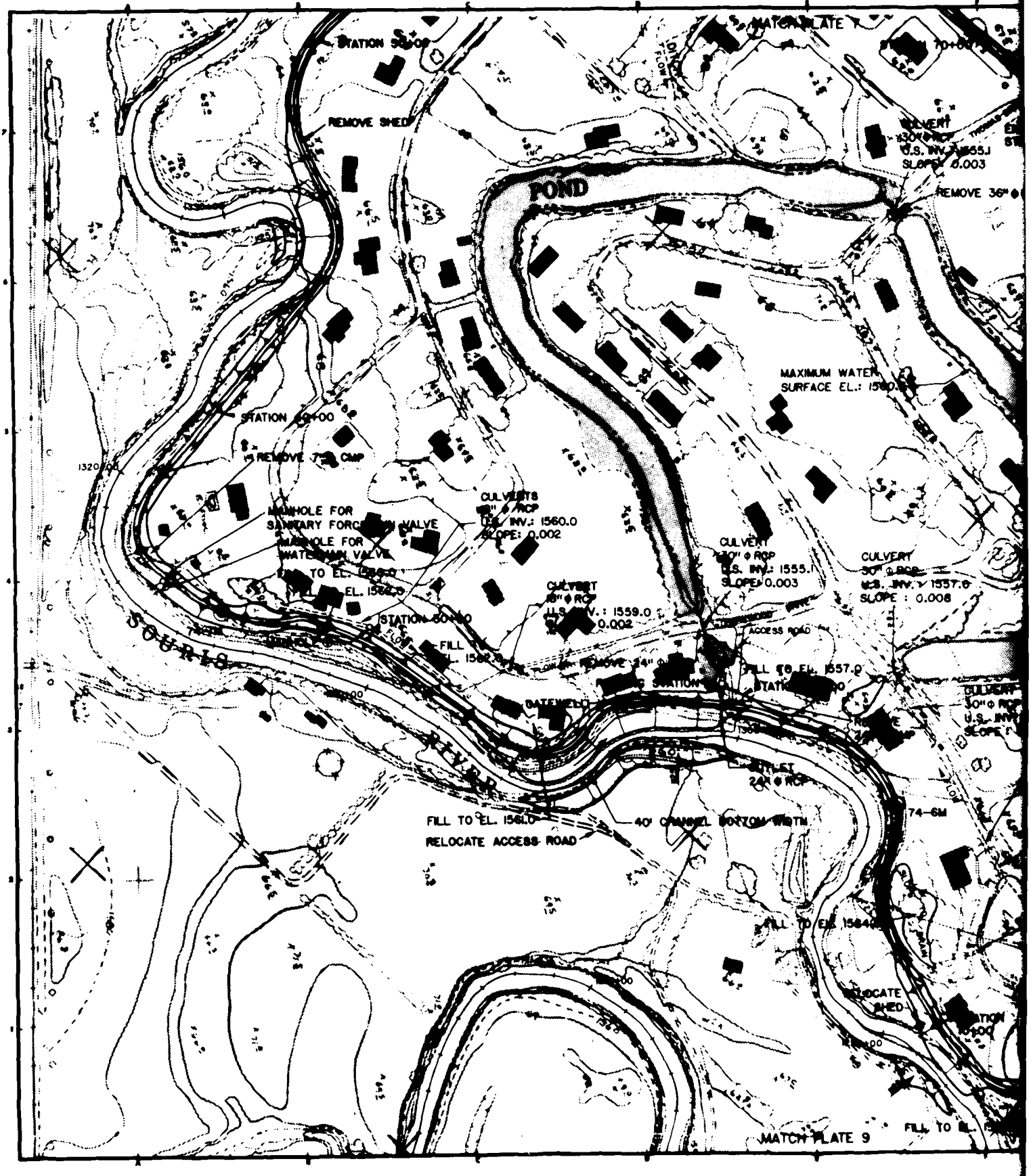

MATCH PLATE 6
APPROXIMATE ℄
MINOT C.C. LEVEE
END LEVEE
STATION 28+60
RELOCATE MOBILE
HOME
SOURIS
MAXIMUM WATER SURFACE EL. 1565.0
TALBOT'S NURSERY
CULVERT
24"ø RCP
U.S. INV. 1562.0
SLOPE: 0.0020
RELOCATE MOBILE HOME
CULVERT
24"ø RCP
U.S. INV. 1560.0
SLOPE: 0.0040
CULVERT
24"ø RCP
U.S. INV. 1560.0
SLOPE: 0.0079
APPROXIMATE ℄
MINOT C.C. LEVEE
POND
COUNTRY CLUB ACRES
NW PORTION
CULVERT
24"ø RCP
U.S. INV. 1560.0
SLOPE: 0.003
BEGIN LEVEE
STATION 0+00
MATCH PLATE

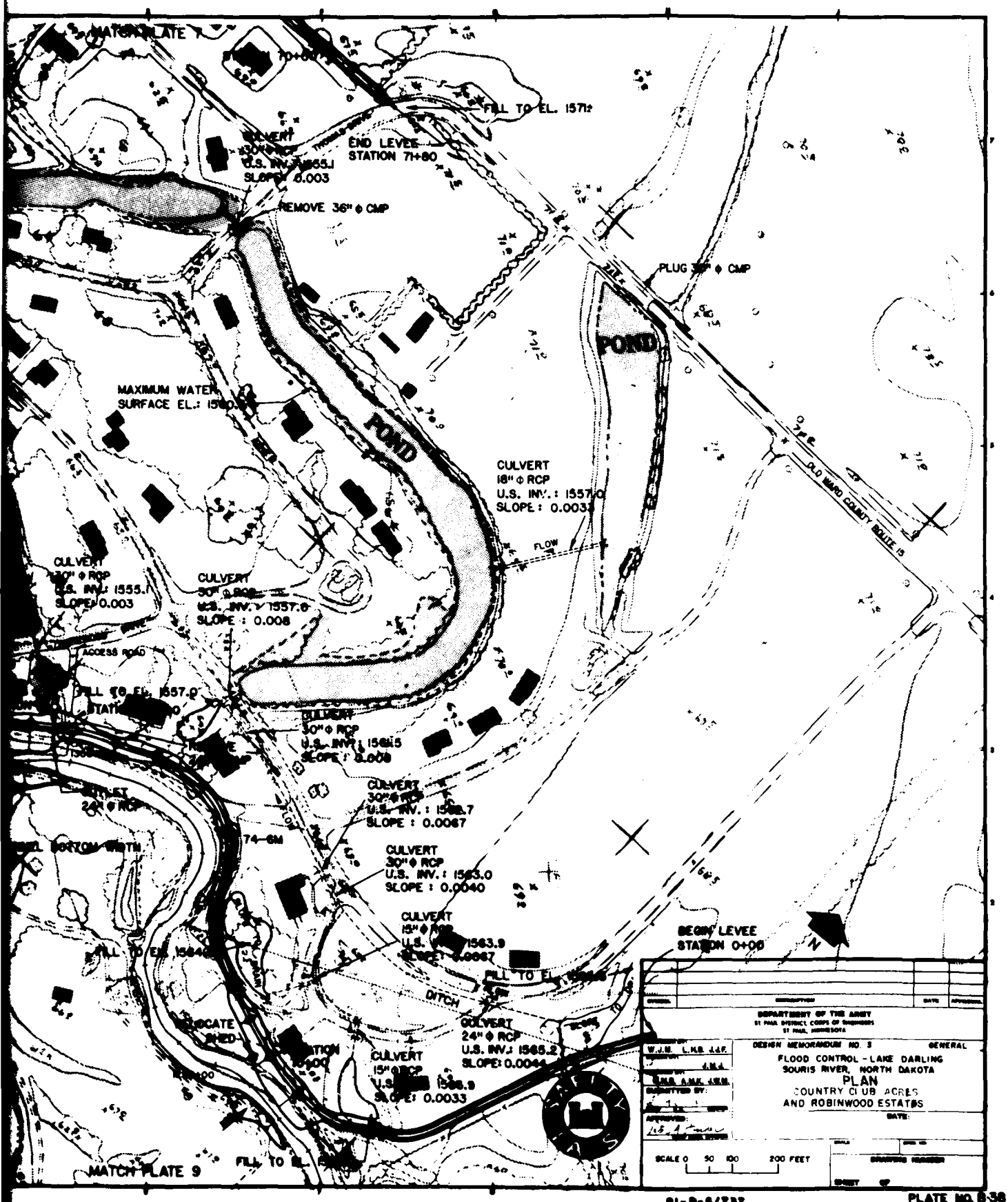
RI-R-8/736

PLATE NO. B-37

1

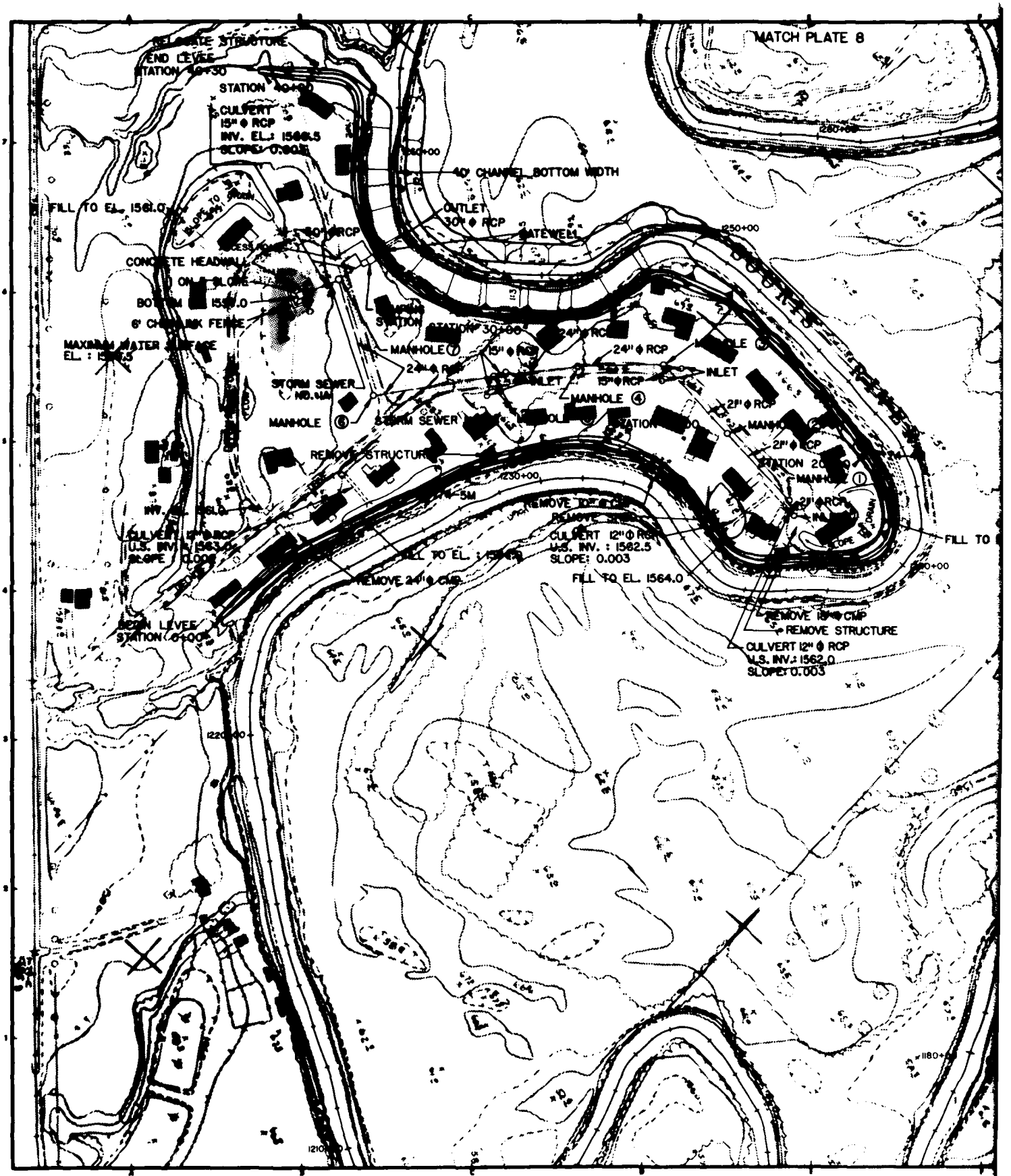
2

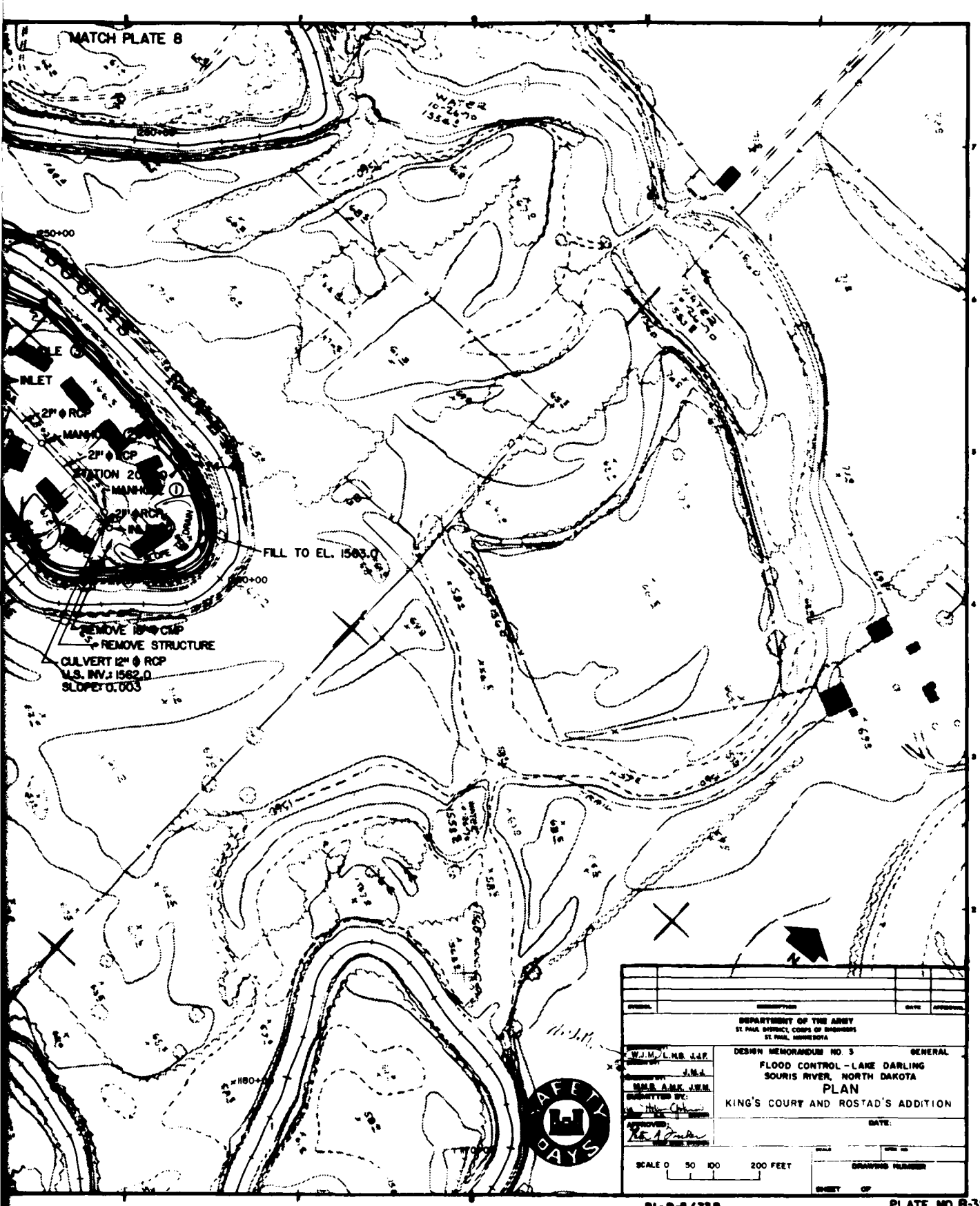

MATCH PLATE 7
REMOVE SHED
POND
CULVERT
30" ϕ RCP
U.S. INV.: 1555.1
SLOPE: 0.003
REMOVE 36" ϕ
MAXIMUM WATER
SURFACE EL.: 1560.0
STATION 60+00
REMOVE 72" CMP
MANHOLE FOR
SANITARY FORCE MAIN VALVE
MANHOLE FOR
WATERMAIN VALVE
CULVERTS
30" ϕ RCP
U.S. INV.: 1560.0
SLOPE: 0.002
CULVERT
30" ϕ RCP
U.S. INV.: 1555.1
SLOPE: 0.003
CULVERT
30" ϕ RCP
U.S. INV.: 1557.6
SLOPE: 0.008
CULVERT
30" ϕ RCP
U.S. INV.: 1559.0
SLOPE: 0.002
STATION 50+00
ACCESS ROAD
FILL TO EL. 1557.0
REMOVE 24" ϕ
GATEWELL
OUTLET
24" ϕ RCP
FILL TO EL. 1561.0
40' CHANNEL BOTTOM WIDTH
RELOCATE ACCESS ROAD
RELOCATE
SHED
MATCH PLATE 9



RI-R-8/737

PLATE NO. 8-38

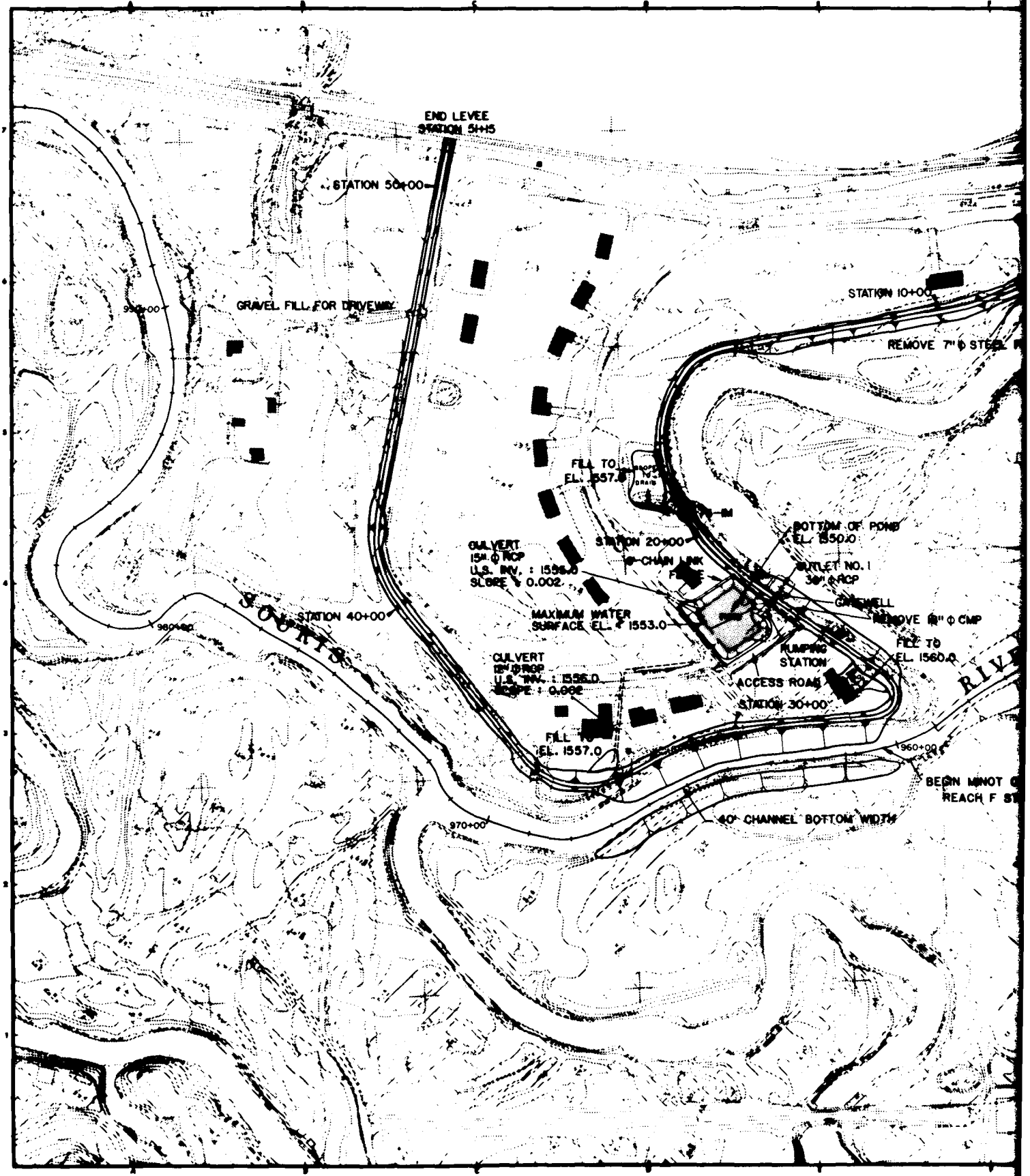

MATCH PLATE 8
RELEASE STRUCTURE
END LEVEE
STATION 40+30
STATION 40+00
CULVERT
15" ϕ RCP
INV. EL.: 1566.5
SLOPE: 0.003
40' CHANNEL BOTTOM WIDTH
OUTLET
30" ϕ RCP
GATEWELL
FILL TO EL. 1561.0
SLOPE TO DRAIN
30" ϕ RCP
CONCRETE HEADWALL
ON 1:1 SLOPE
BOTTOM EL. 1559.0
6' CHAIN LINK FENCE
MAXIMUM WATER SURFACE
EL. : 1565.5
STORM SEWER
NO. 4A
MANHOLE ⑤
STORM SEWER
REMOVE STRUCTURE
INV. EL. 1561.0
CULVERT 12" ϕ RCP
U.S. INV.: 1563.0
SLOPE: 0.003
FILL TO EL. 1564.0
REMOVE 24" ϕ CMP
BEGIN LEVEE
STATION 0+00
STATION 30+00
24" ϕ RCP
MANHOLE ⑦
15" ϕ RCP
24" ϕ RCP
INLET
15" ϕ RCP
INLET
MANHOLE ④
21" ϕ RCP
MANHOLE ③
21" ϕ RCP
STATION 20+00
MANHOLE ①
21" ϕ RCP
INLET
REMOVE 15" ϕ RCP
REMOVE STRUCTURE
REMOVE 12" ϕ RCP
REMOVE STRUCTURE
CULVERT 12" ϕ RCP
U.S. INV.: 1582.5
SLOPE: 0.003
FILL TO EL. 1564.0
REMOVE 15" ϕ CMP
REMOVE STRUCTURE
CULVERT 12" ϕ RCP
U.S. INV.: 1562.0
SLOPE: 0.003
FILL TO
SLOPE TO DRAIN
1250+00
1230+00
1220+00
1210+00
1180+00
280+00
260+00

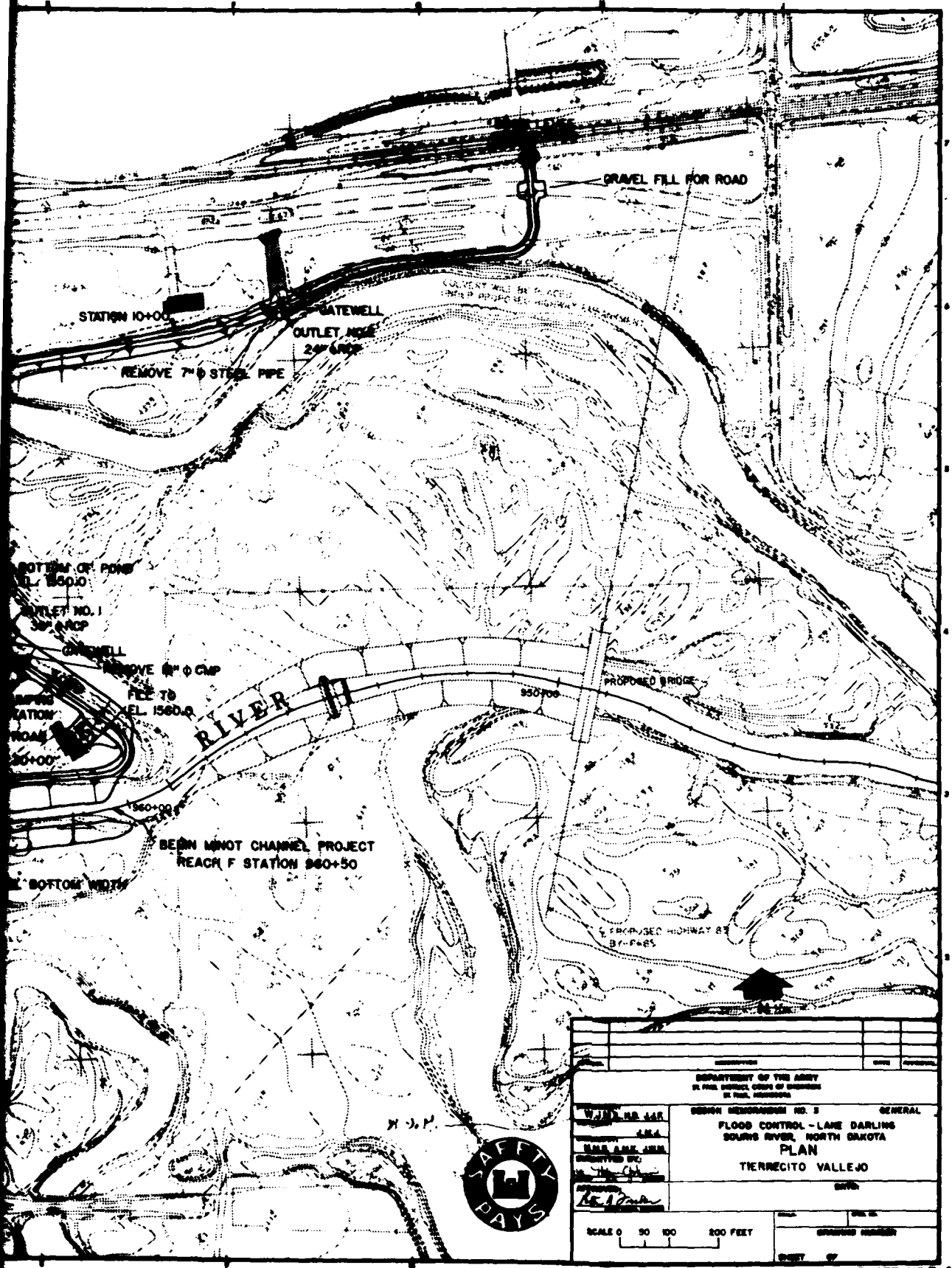


RI-R-8/738

PLATE NO. B-39

1 2

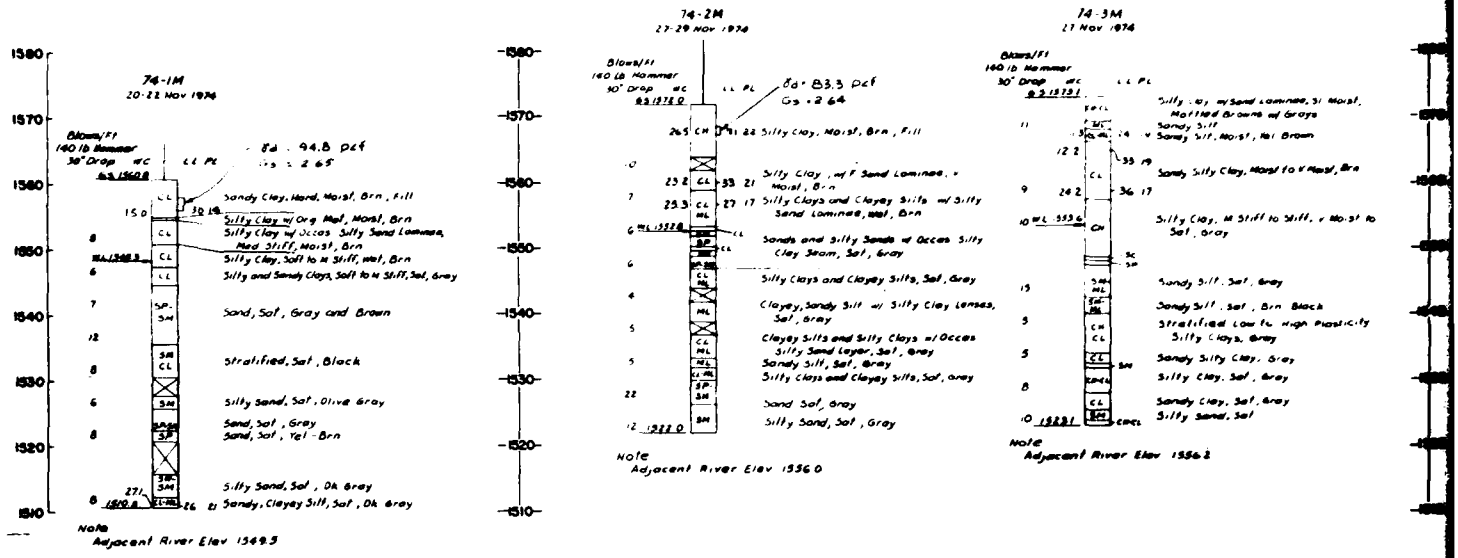

END LEVEE
STATION 51+15
STATION 50+00
GRAVEL FILL FOR DRIVEWAY
STATION 10+00
REMOVE 7" Φ STEEL
FILL TO
EL. 1557.0
STATION 20+00
CULVERT
15" Φ RCP
U.S. INV. : 1558.0
SLOPE : 0.002
BOTTOM OF POND
EL. 1550.0
OUTLET NO. 1
36" Φ RCP
CAISSON
REMOVE 18" Φ CMP
FILL TO
EL. 1560.0
MAXIMUM WATER
SURFACE EL. = 1553.0
STATION 40+00
SOURIS
CULVERT
12" Φ RCP
U.S. INV. : 1556.0
SLOPE : 0.002
PUMPING
STATION
ACCESS ROAD
STATION 30+00
FILL TO
EL. 1557.0
960+00
970+00
40' CHANNEL BOTTOM WIDTH
BEGIN MINOT
REACH F ST
RIV



RI-R-B/739

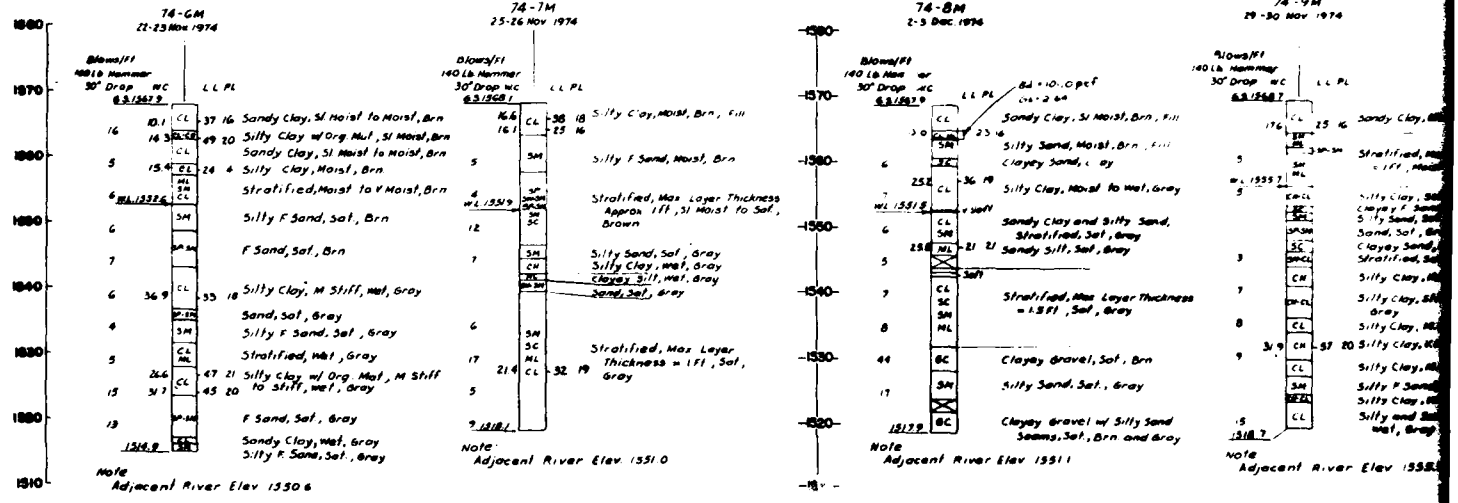
PLATE NO. B-40

1 2



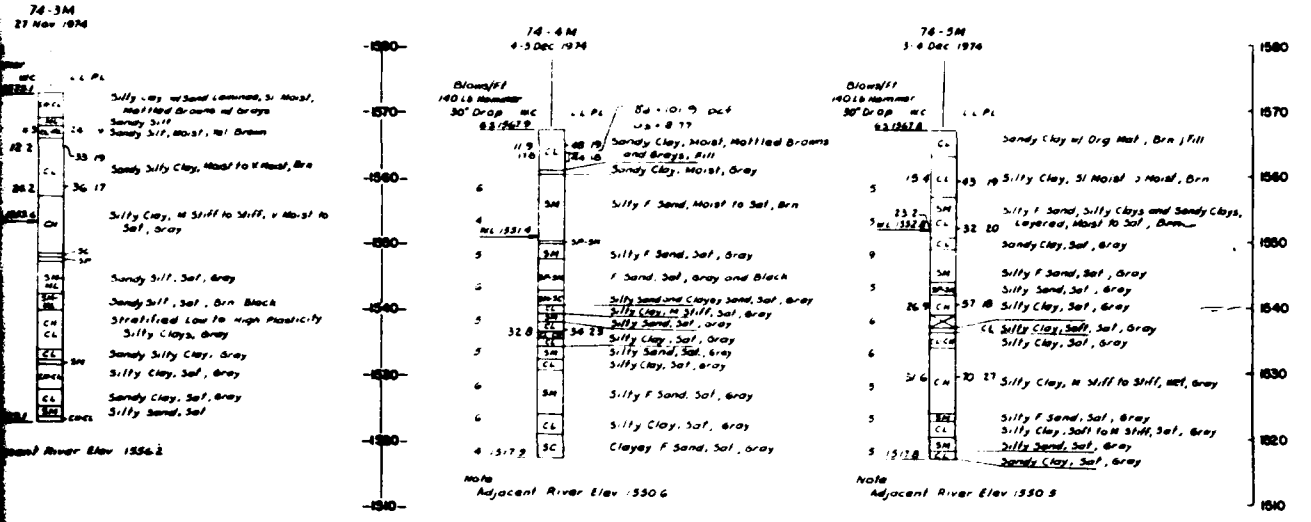
TIERRECITO VALLEJO

JOHNSON'S ADDITION

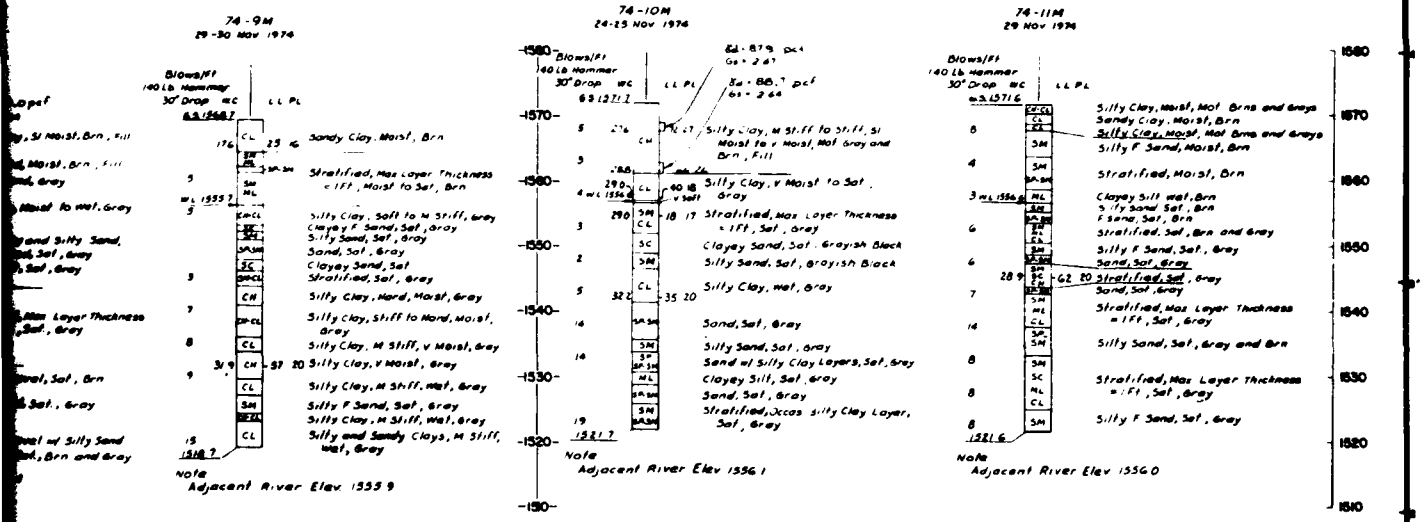


COUNTRY CLUB ACRES AND ROBINWOOD ESTATES

TALBOTS NURSERY



KINGS COURT AND ROSTAD'S ADDITION



TALBOTS NURSERY

BROOK'S ADDITION

DIVISION	DESCRIPTION	DATE	APPROVED

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
ST PAUL, MINNESOTA

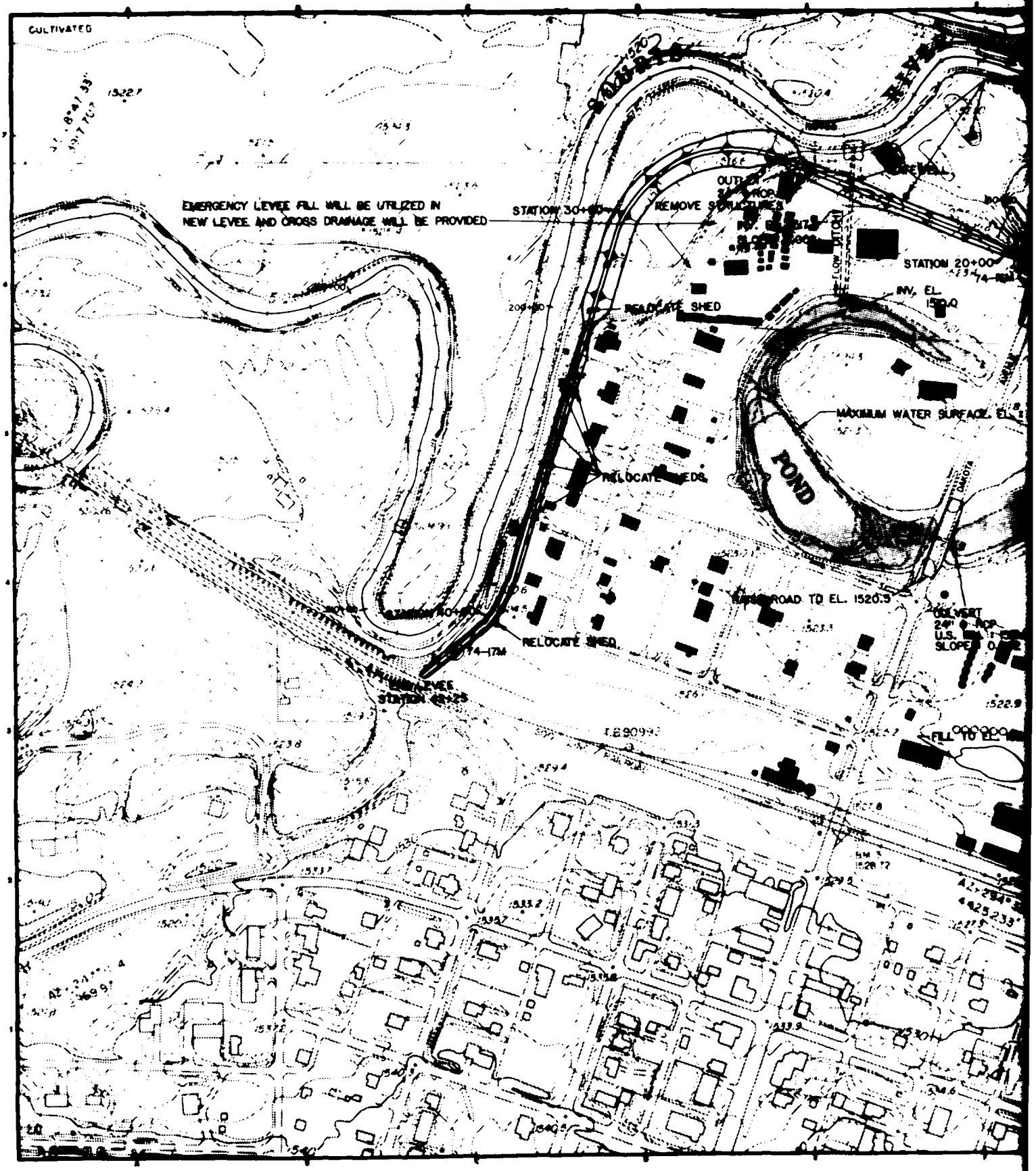
DESIGNED BY: L.H.B
DRAWN BY: J.M.J
CHECKED BY: M.M.B.
SUBMITTED BY:
APPROVED:

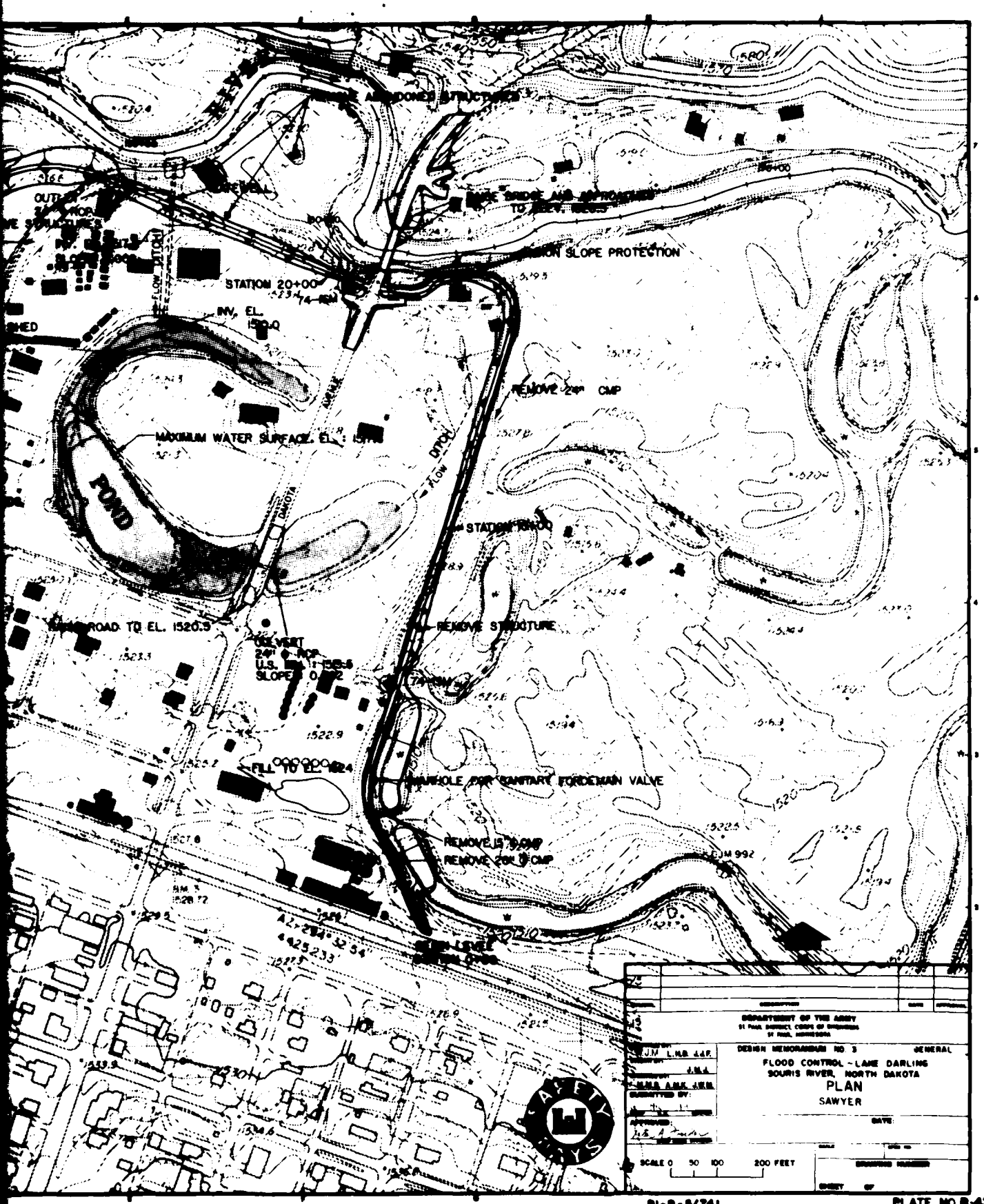
DESIGN MEMORANDUM NO. 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
LEVEE-BURLINGTON TO MINOT
BORINGS 74-1M THRU 74-11M

DATE: JUNE 1983
SCALE
DRAWING NUMBER
RI-R-5/740
SHEET OF

SAFETY PAYS

PLATE NO. B-41


CULTIVATED
EMERGENCY LEVEE FILL WILL BE UTILIZED IN NEW LEVEE AND CROSS DRAINAGE WILL BE PROVIDED
STATION 30+00
REMOVE STRUCTURES
STATION 20+00
INV. EL. 1520.0
RELOCATE SHED
MAXIMUM WATER SURFACE EL.
POND
RELOCATE SHED
RAISE ROAD TO EL. 1520.5
RELOCATE SHED
FILL TO EL.

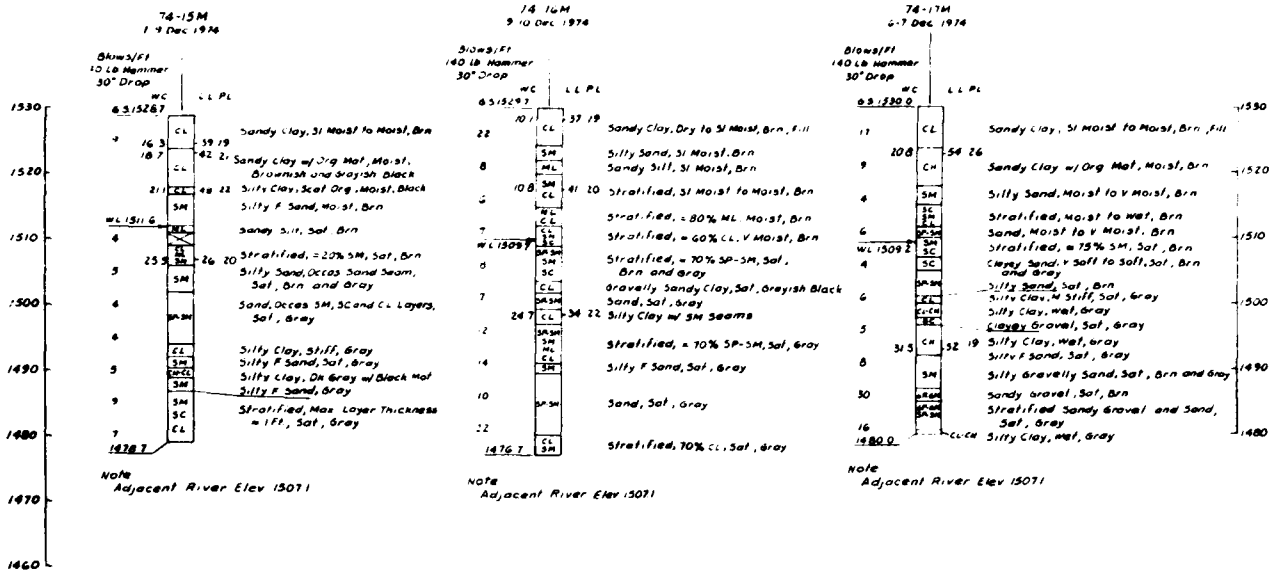


RI-R-8/741

PLATE NO. B-42

1 2

CORPS OF ENGINEERS



E F G H J

1550

Clay, Si Moist to Moist, Brn, Fill

Clay w/ Org Mat, Moist, Brn — 520

Sand, Moist to v Moist, Brn

Sand, Moist to wet, Brn
Moist to v Moist, Brn — 510
Sand, ± 75% SM, Sat, Brn
Sand, v Soft to Soft, Sat, Brn
Gray
Sand, Sat, Brn
Clay, M Stiff, Sat, Gray — 500
Clay, wet, Gray
Gravel, Sat, Gray
Clay, Wet, Gray
Sand, Sat, Gray
Gravelly Sand, Sat, Brn and Gray — 490
Gravel, Sat, Brn
Sand Sandy Gravel and Sand,
Gray
Clay, wet, Gray — 480

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
ST PAUL, MINNESOTA

DESIGNED BY: L H B
DRAWN BY: J. M. J.
CHECKED BY: MM: B
SUBMITTED BY:
APPROVED:

DESIGN MEMORANDUM NO. 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
SAWYER
BORINGS 74-15M 74-17M

DATE: JUNE 1983

SCALE: AS SHOWN
DRAWING NUMBER
RI-R-5/742
SHEET OF

SAFETY PAYS

E F G

PLATE NO. B-43

1 2

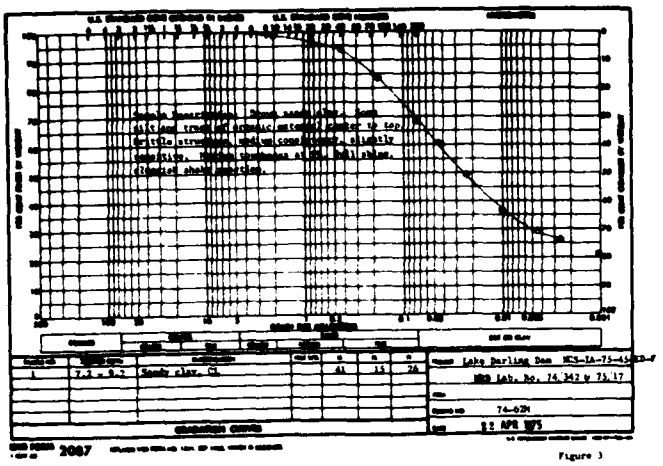
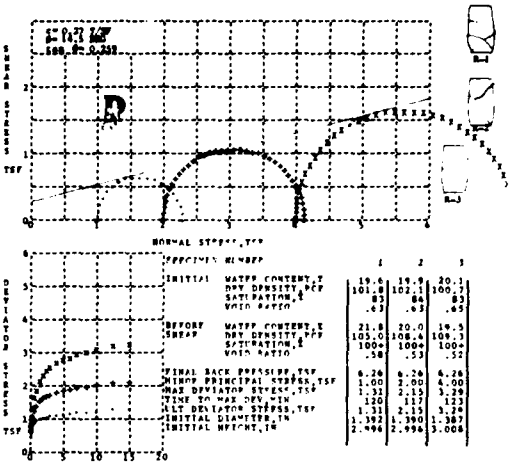


Figure 3

①



NORMAL STRESS,TSF

SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT,%	19.6	19.9	20.1
	DRY DENSITY,PCF	101.8	102.1	100.3
	SATURATION,%	83	86	83
	VOID RATIO	.63	.63	.65
BEFORE SHEAR	WATER CONTENT,%	21.8	20.0	19.5
	DRY DENSITY,PCF	103.0	108.6	109.3
	SATURATION,%	100+	100+	100+
	VOID RATIO	.58	.53	.52
FINAL BACK PRESSURE,TSF		6.26	6.26	6.26
MINOR PRINCIPAL STRESS,TSF		1.00	2.00	4.00
MAX DEVIATOR STRESS,TSF		1.31	2.15	3.29
TIME TO MAX DEV,MIN		130	117	121
ULT DEVIATOR STRESS,TSF		1.31	2.15	3.29
INITIAL DIAMETER,IN		1.392	1.390	1.387
INITIAL HEIGHT,IN		2.996	2.996	3.006

AXIAL STRAIN,%

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

LL 41 PL 15 PI 26 Gs= 2.66 TYPE SPECIMEN: UNDISTURBED TYPE TEST R

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

PROJECT: Lake Darling Dam MCS-1A-75-45-ED-F

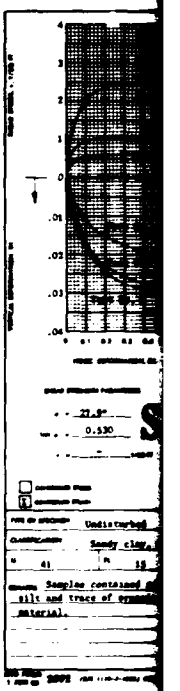
BORING NO: 74-62H SAMPLE NO: 1

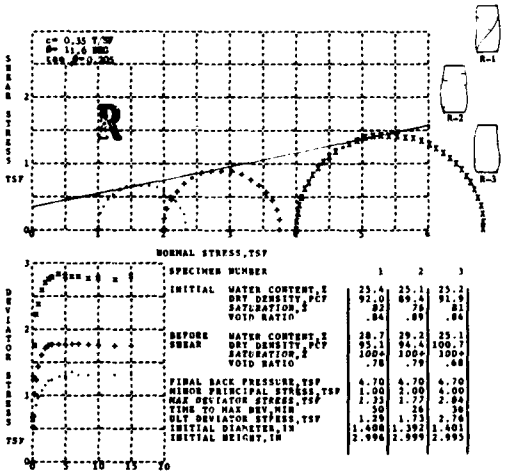
DEPTH: 7.2 - 9.2

WRD LAB NO:74/342 DATE 82 APR 05
6/75/17

TRIAXIAL COMPRESSION TEST REPORT

②





NORMAL STRESS,TSF

SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT,%	23.4	23.1	23.2
	DRY DENSITY,PCF	92.0	89.4	91.9
	SATURATION,%	82	76	81
	VOID RATIO	.84	.89	.84
BEFORE SHEAR	WATER CONTENT,%	28.7	29.2	25.1
	DRY DENSITY,PCF	95.1	94.4	100.7
	SATURATION,%	100+	100+	100+
	VOID RATIO	.78	.79	.68
FINAL BACK PRESSURE,TSF		4.70	4.70	4.70
MINOR PRINCIPAL STRESS,TSF		1.00	2.00	4.00
MAX DEVIATOR STRESS,TSF		1.33	1.77	2.84
TIME TO MAX DEV,MIN		50	26	36
ULT DEVIATOR STRESS,TSF		1.29	1.73	2.76
INITIAL DIAMETER,IN		1.408	1.392	1.401
INITIAL HEIGHT,IN		2.996	2.999	2.993

AXIAL STRAIN,%

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

LL 45 PL 19 PI 26 Gs= 2.71 TYPE SPECIMEN: UNDISTURBED TYPE TEST R

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

PROJECT: Lake Darling Dam MCS-1A-75-45-ED-F

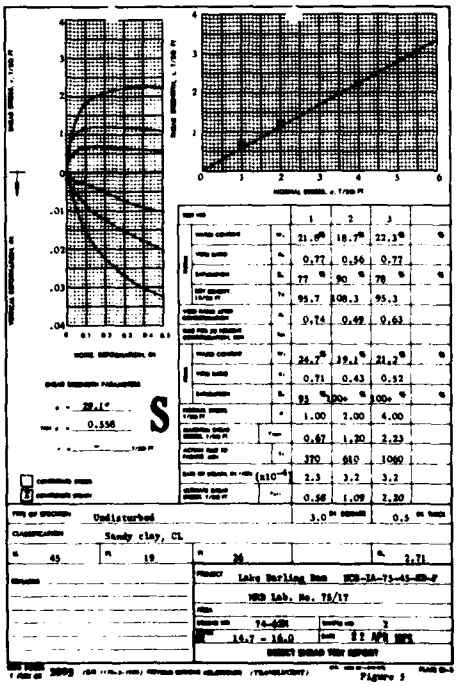
BORING NO: 74-62H SAMPLE NO: 2

DEPTH: 14.7 - 16.0

WRD LAB NO: 74/342 DATE 82 APR 05
6/75/17

TRIAXIAL COMPRESSION TEST REPORT

⑤



		1	2	3	
		21.6	18.7	22.3	%
		0.77	0.56	0.77	
		77	90	78	%
		95.7	108.3	95.3	
		0.76	0.49	0.63	
		26.7	19.1	21.2	%
		0.71	0.43	0.52	
		93	100+	100+	%
		1.00	2.00	4.00	
		0.67	1.20	2.23	
		370	910	1060	
		2.3	3.2	3.2	
		0.56	1.09	2.20	

TYPE OF SPECIMEN	Undisturbed	3.0 IN DIAMETER	0.5 IN THICK
CLASSIFICATION	Sandy clay, CL		
LL 45	PL 19	PI 26	Gs 2.71

PROJECT Lake Darling Dam MCS-1A-75-45-ED-F

WRD Lab. No. 75/17

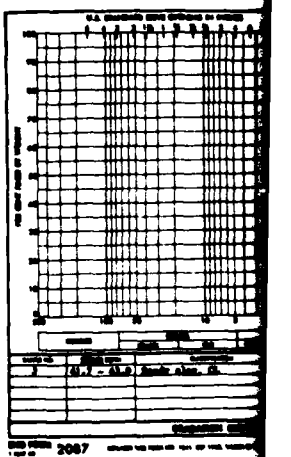
BORING NO. 74-62H SAMPLE NO. 2

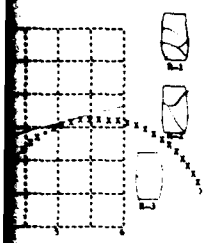
DEPTH 14.7 - 16.0 DATE 82 APR 05

DIRECT SHEAR TEST REPORT

Figure 5

⑥





	1	2	3
	19.6	19.9	20.1
	101.8	102.1	100.7
	83	86	83
	.63	.63	.65
	21.8	20.0	19.5
	103.0	109.6	109.3
	100+	100+	100+
	.58	.53	.52
	6.26	6.26	6.26
	1.00	2.00	4.00
	1.31	2.15	3.29
	120	117	123
	1.31	2.13	3.29
	1.392	1.390	1.387
	2.996	2.996	3.008

UNDISTURBED TYPE TEST R

Lake Darling Dam MCS-1A-73-45-ED-F

74-62M SAMPLE NO: 1

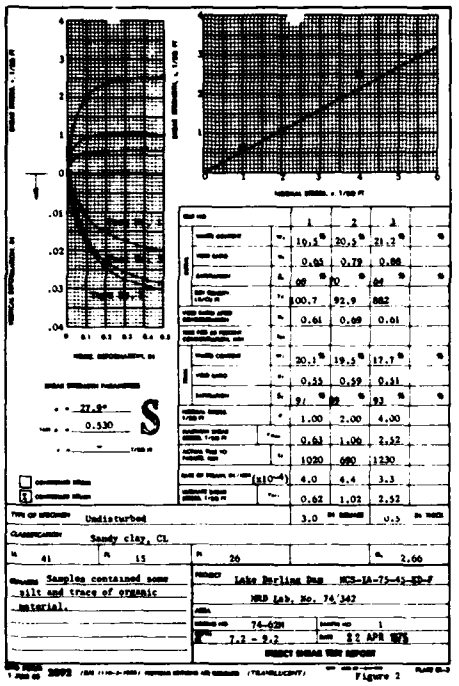
9.2

74/342 DATE 22 APR 1975

74/17

COMPRESSION TEST REPORT

FIGURE 1



	1	2	3
	10.5 %	20.2 %	21.2 %
	0.65	0.79	0.86
	88 %	70 %	64 %
	100.7	92.9	882
	0.61	0.69	0.61
	20.1 %	19.5 %	17.7 %
	0.53	0.59	0.61
	91 %	89 %	93 %
	1.00	2.00	4.00
	0.63	1.06	2.52
	1020	680	1230
	4.0	4.4	3.3
	0.62	1.02	2.52
	3.0		0.5

ϕ = 27.8°

S = 0.530

TYPE OF SPECIMEN: Undisturbed

CLASSIFICATION: Sandy clay, CL

LL 41 PL 15 PI 26 Gs 2.66

REMARKS: Samples contained some silt and trace of organic material.

PROJECT: Lake Darling Dam MCS-1A-73-45-ED-F

MRD Lab. No. 74/342

SOURCE NO. 74-62M SAMPLE NO. 1

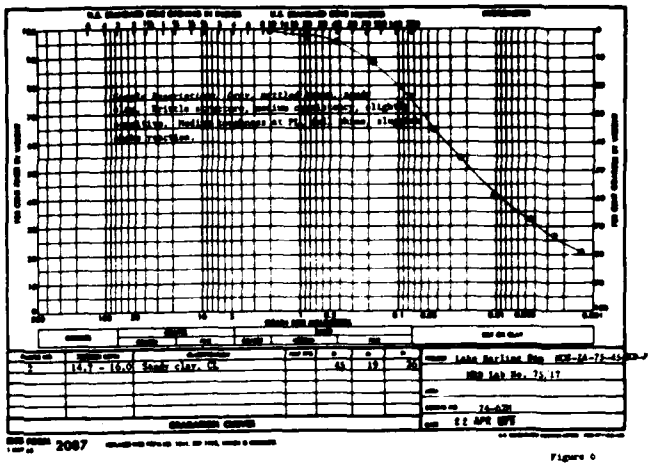
DEPTH 7.2 - 9.2 DATE 22 APR 1975

DIRECT SHEAR TEST REPORT

2087

Figure 2

③



2	14.7 - 16.0	Sandy clay, CL			45	19	26

Lake Darling Dam MCS-1A-73-45-ED-F

MRD Lab No. 74,17

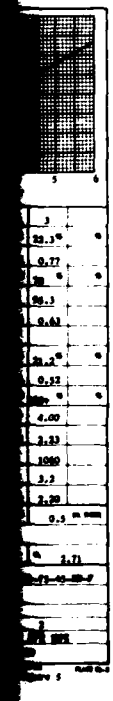
SOURCE NO. 74-62M

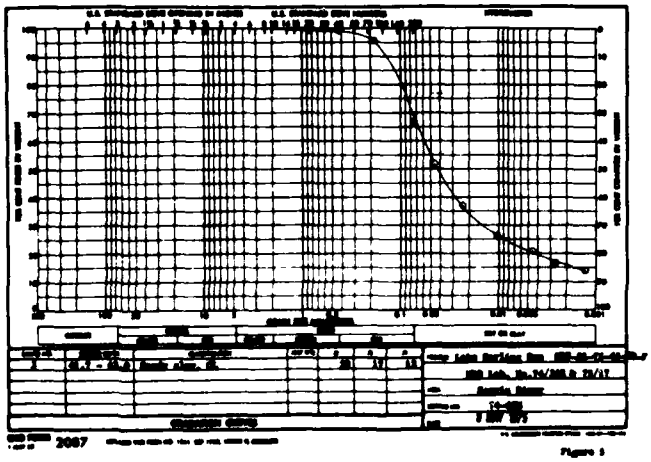
DATE 22 APR 1975

2087

Figure 6

④

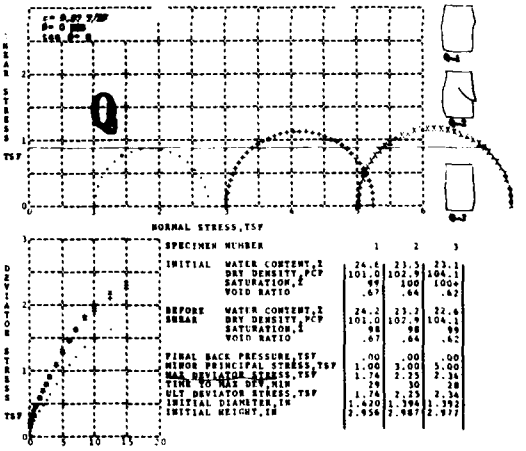




2087

Figure 5

⑦



NORMAL STRESS, TSF

SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT, %	24.6	23.5	23.1
	DRY DENSITY, PCF	101.0	102.9	104.1
	SATURATION, %	99	100	100+
	VOID RATIO	.67	.64	.62
BEFORE SHEAR	WATER CONTENT, %	24.2	23.2	22.6
	DRY DENSITY, PCF	101.0	102.9	104.1
	SATURATION, %	98	98	99
	VOID RATIO	.67	.64	.62
FINAL BACK PRESSURE, TSF		.00	.00	.00
MINOR PRINCIPAL STRESS, TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS, TSF		1.74	2.13	2.34
TIME TO MAX DEV, MIN		.29	.30	.28
ULT DEVIATOR STRESS, TSF		1.74	2.25	3.34
INITIAL DIAMETER, IN		1.420	1.394	1.394
INITIAL HEIGHT, IN		2.956	2.987	2.977

AXIAL STRAIN, %

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

LL 39 PL 17 PI 22 Gs= 2.70 TYPE SPECIMEN: UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2089

Brown sandy clay, brittle structure, medium consistency, slightly sensitive. Low toughness at PL, no shine, slow dilatancy reaction.

PROJECT: Lake Darling Dam MCS-1A-73-45-ED-F

BORING NO: 74-62M SAMPLE NO: 3

DEPTH: 44.7 - 45.0

MRD LAB NO: 74/342 DATE 8 MAY 1975

74/17

TRIAXIAL COMPRESSION TEST REPORT

FIGURE 8

⑧

DESIGN MEMORANDUM NO. 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

SOILS TEST DATA
LAKE DARLING DAM

BORING 74-62 M

ST PAUL, MINN DISTRICT

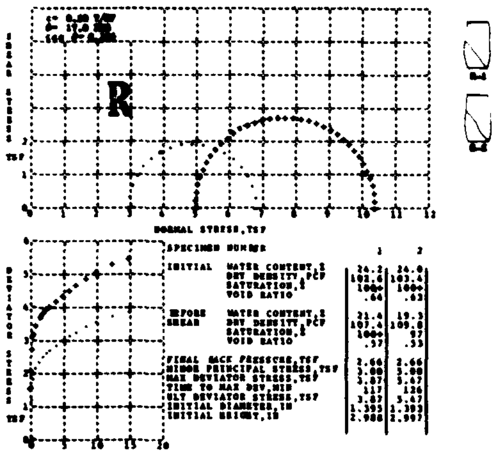
JUNE 1983

PLATE NO. B-44

RI-R-B/763

1

2



SPECIMEN NUMBER		1	2
INITIAL	WATER CONTENT,%	24.2	24.0
	DRY DENSITY,PCF	102.6	103.4
	SATURATION,%	100+	100+
	VOID RATIO	.64	.63
BEFORE SHEAR	WATER CONTENT,%	21.4	19.3
	DRY DENSITY,PCF	107.4	109.8
	SATURATION,%	100+	97
	VOID RATIO	.57	.53
FINAL BACK PRESSURE,TSF		2.66	2.66
MINOR PRINCIPAL STRESS,TSF		3.00	5.00
MAX DEVIATOR STRESS,TSF		3.87	5.47
TIME TO MAX DEV,MIN		117	126
ULT DEVIATOR STRESS,TSF		3.87	5.47
INITIAL DIAMETER,IN		1.393	1.393
INITIAL HEIGHT,IN		2.988	2.997

CONTROLLED-STRAIN TEST

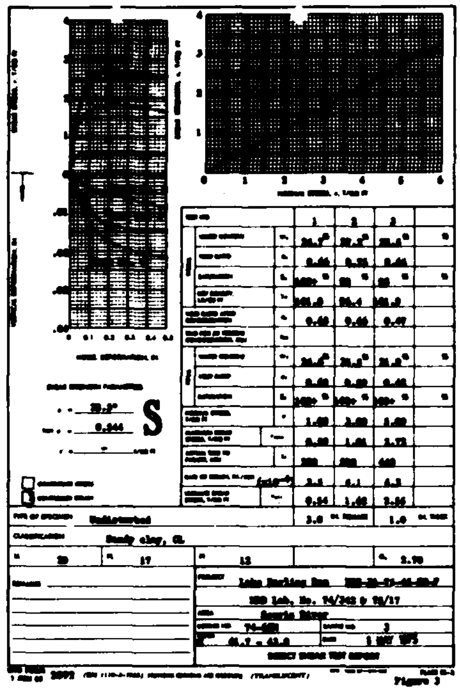
DESCRIPTION OF SPECIMENS: Sandy clay, CL

LL 29 PL 17 PI 12 Gs= 2.70 TYPE SPECIMEN: UNDISTURBED TYPE TEST R

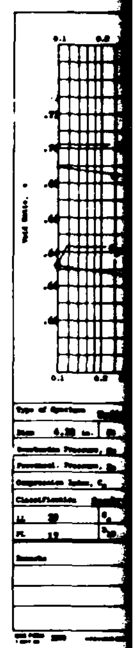
REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089
R test at 1.0 T/SF minor principal stress had equipment malfunction during shear.

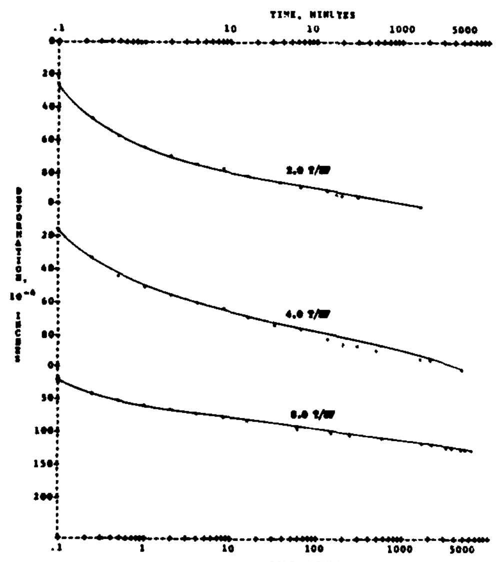
PROJECT: Lake Darling Dam — Souris River
BORING NO: 74-46M SAMPLE NO: 3
DEPTH: 41.7 - 43.0
NRD LAB NO: 74/362 & 75/17 DATE 5 MAY 1975
TRIAXIAL COMPRESSION TEST REPORT
FIGURE 3

①



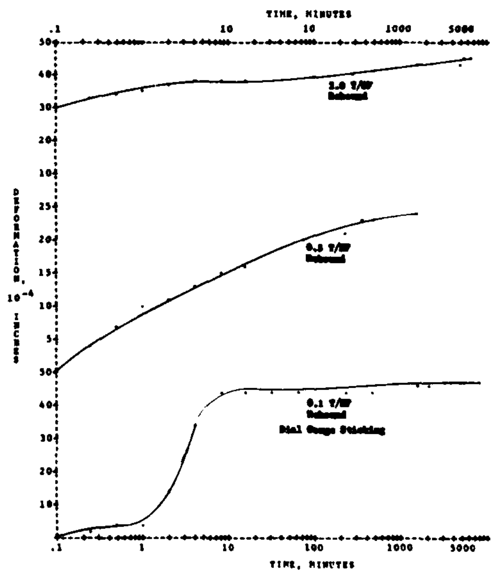
②





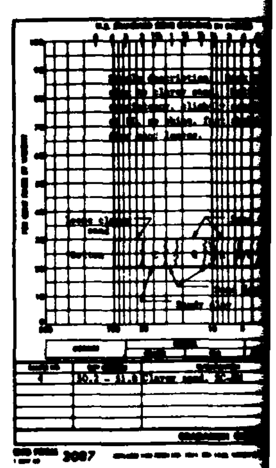
PROJECT: Lake Darling Dam
NRD LABORATORY NO: 74/362 & 75/17
BORING NO: 74-46M SAMPLE NO: 3 DEPTH: 41.7 - 43.0 DATE: 8 MAY 1975
CONSOLIDATION TEST -- TIME CURVES
MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088
FIGURE 4b

⑤

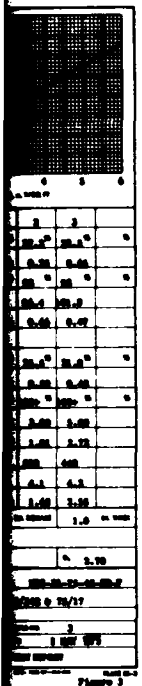


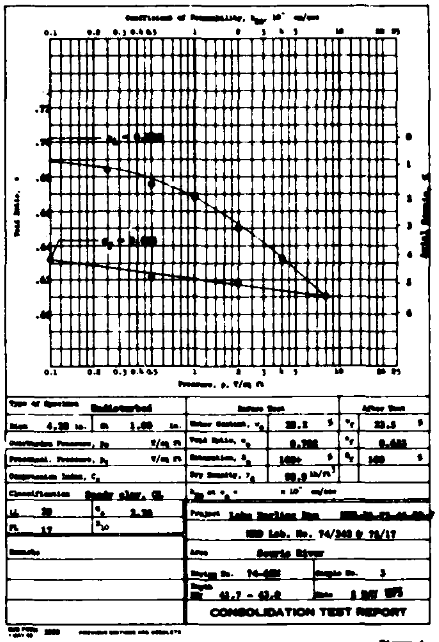
PROJECT: Lake Darling Dam
NRD LABORATORY NO: 74/362 & 75/17
BORING NO: 74-46M SAMPLE NO: 3 DEPTH: 41.7 - 43.0 DATE: 8 MAY 1975
CONSOLIDATION TEST -- TIME CURVES
MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088
FIGURE 4a

⑥

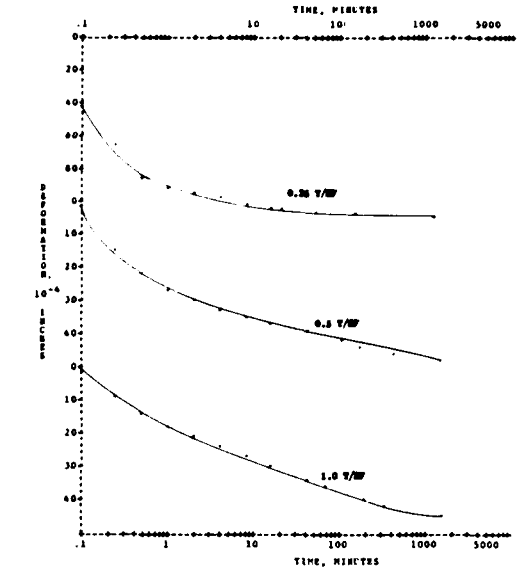


U. S. ARMY





③



PROJECT: Lake Darling Dam

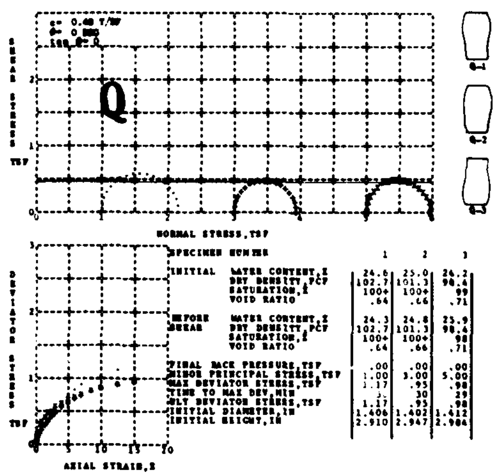
NRD LABORATORY NO: 74/342 & 75/17

BORING NO: 74-62M SAMPLE NO: 3 DEPTH: 41.7 - 43.0 DATE: 1 MAY 1975

CONSOLIDATION TEST -- TYPE CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088 FIGURE 4a

④



SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT,%	24.6	25.0	26.2
	DRY DENSITY,PCF	102.7	101.3	98.4
	SATURATION,%	100+	100+	99
	VOID RATIO	.64	.66	.71
BEFORE SHEAR	WATER CONTENT,%	24.3	24.8	25.9
	DRY DENSITY,PCF	102.7	101.3	98.4
	SATURATION,%	100+	100+	98
	VOID RATIO	.64	.66	.71
FINAL BACK PRESSURE,TSF		.00	.00	.00
MINOR PRINCIPAL STRESS,TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS,TSF		1.17	.95	.98
TIME TO MAX DEV,MIN		[illegible]	30	29
ULT DEVIATOR STRESS,TSF		1.17	.95	.98
INITIAL DIAMETER,IN		1.406	1.402	1.412
INITIAL HEIGHT,IN		2.910	2.947	2.984

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Clayey sand, SC-SM

LL 25 PL 19 PI 6 Gs= 2.70 TYPE SPECIMEN: UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

PROJECT: Lake Darling Dam

BORING NO: 74-62M SAMPLE NO: 4

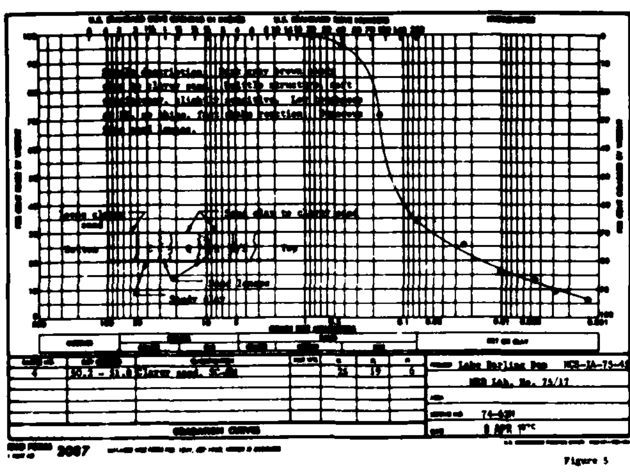
DEPTH: 50.2 - 51.0

NRD LAB NO: 74/342 & 75/17 DATE 8 APR 1975

TRIAXIAL COMPRESSION TEST REPORT

FIGURE 8

⑧



⑦

DESIGN MEMORANDUM NO. 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

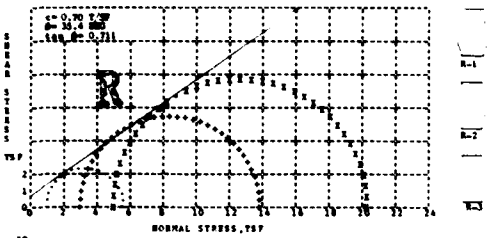
SOILS TEST DATA
LAKE DARLING DAM

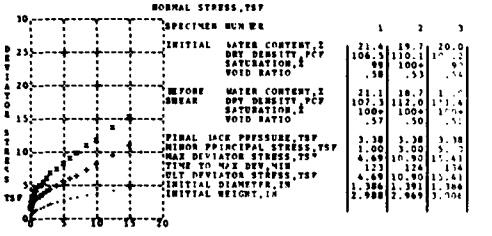
BORING 74-62M

ST PAUL, MINN DISTRICT

JUNE 1983

PLATE NO. B-45





SPECIMEN NUMBER			1	2	3
INITIAL	WATER CONTENT, %		21.4	19.7	20.0
	DRY DENSITY, PCF		106.5	110.1	109.2
	SATURATION, %		98	100+	97
	VOID RATIO		.58	.53	.54
BEFORE SHEAR	WATER CONTENT, %		21.1	18.7	19.6
	DRY DENSITY, PCF		107.3	112.0	111.4
	SATURATION, %		100+	100+	100+
	VOID RATIO		.57	.50	.51
FINAL BACK PRESSURE, TSF			3.38	3.38	3.38
MINOR PRINCIPAL STRESS, TSF			1.00	3.00	5.00
MAX DEVIATOR STRESS, TSF			4.69	10.90	13.41
TIME TO MAX DEV, MIN			123	124	134
ULT DEVIATOR STRESS, TSF			4.69	10.90	13.41
INITIAL DIAMETER, IN			1.386	1.391	1.386
INITIAL HEIGHT, IN			2.988	2.965	2.706

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Clayey sand, SC-SM

LL 25 PL 19 PI 6 Gs= 2.70 TYPE SPECIMEN: UNDISTURBED TYPE TEST R

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

PROJECT: Lake Darling Dam MCS-IA-75-45-ED-F

BORING NO: 74-62M SAMPLE NO: 4

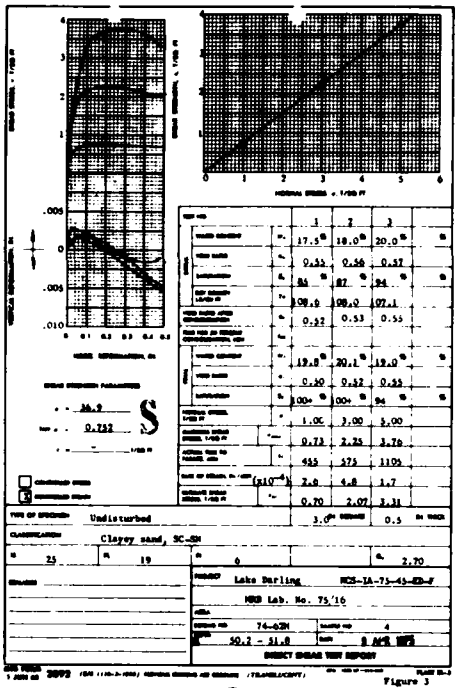
DEPTH: 50.2 - 51.8

MRD LAB NO: 74/342 & 75/17 DATE 9 APR 1975

TRIAXIAL COMPRESSION TEST REPORT

FIGURE 2

①



	1	2	3
	17.5	18.0	20.0
	0.55	0.56	0.57
	84	87	94
	98.0	98.0	97.1
	0.52	0.53	0.55
	19.8	20.1	19.0
	0.50	0.52	0.55
	100+	100+	94
	1.00	3.00	5.00
	0.73	2.25	3.76
	455	575	1105
	2.0	4.8	1.7
	0.70	2.07	3.31

Undisturbed

Clayey sand, SC-SM

Lake Darling MCS-IA-75-45-ED-F

MRD Lab. No. 75'16

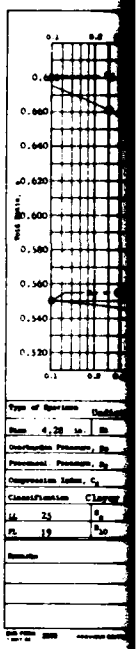
74-62M 4

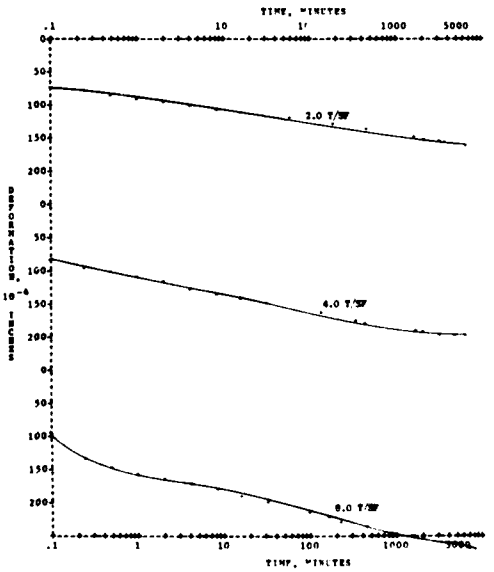
50.2 - 51.8 9 APR 1975

DIRECT SHEAR TEST REPORT

Figure 3

②





PROJECT: Lake Darling Dam MCS-IA-75-45-ED-F

MRD LABORATORY NO: 74/342 & 75/17

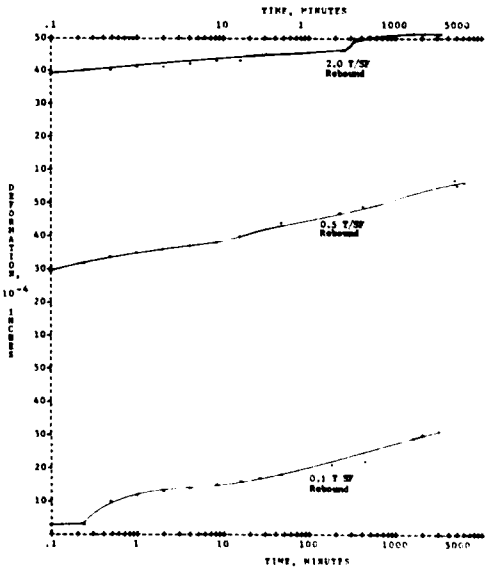
BORING NO: 74-62M SAMPLE NO: 4 DEPTH: 50.2 - 51.8 DATE: 9 APR 1975

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

FIGURE 4b

⑤



PROJECT: Lake Darling Dam MCS-IA-75-45-ED-F

MRD LABORATORY NO: 74/342 & 75/17

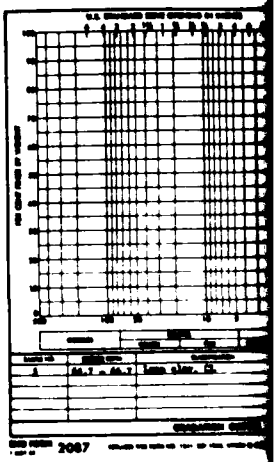
BORING NO: 74-62M SAMPLE NO: 4 DEPTH: 50.2 - 51.8 DATE: 9 APR 1975

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

FIGURE 4c

⑥



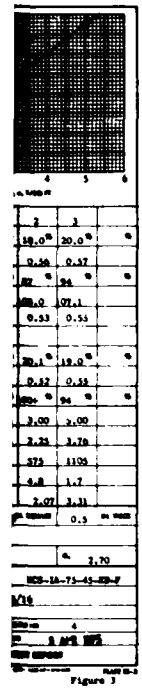
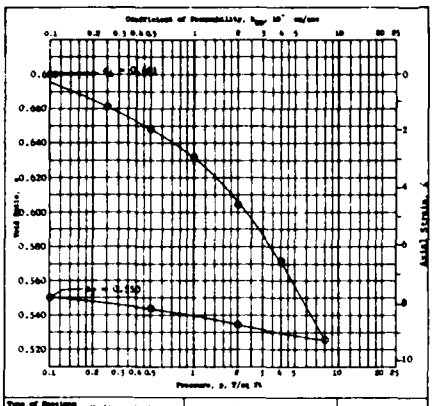


Figure 3

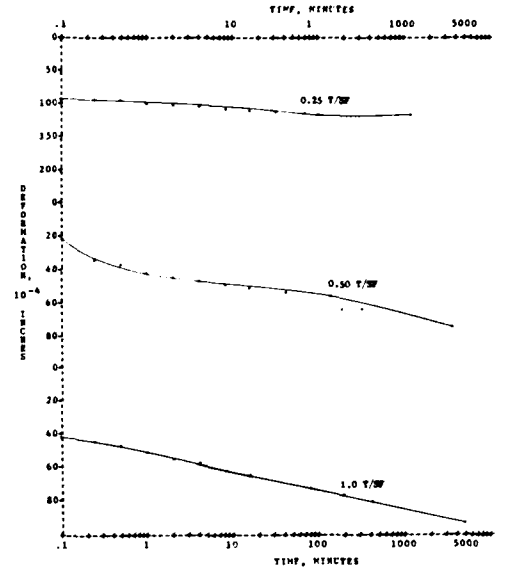


Type of Specimen	Undisturbed	Before Test		After Test	
Diam 4.28 in.	Ht 1.00 in.	Water Content, w_o	20.4 %	w_f	26.1 %
Overburden Pressure, p_o	T/sq ft	Void Ratio, e_o	0.681	e_f	0.530
Preconsol. Pressure, p_c	T/sq ft	Saturation, S_o	81 %	S_f	100+ %
Compression Index, C_c		Dry Density, γ_d	100.2 lb/ft³		
Classification	Clayey sand, SC-SM	k_{20} at e_o =	x 10⁻⁴ cm/sec		
LL 25	G_s 2.70	Project	Lake Darling Dam MCS-1A-75-45-MD-F		
PL 19	D_{10}	MRD Lab. No. 74/342 & 75/17			
Remarks		Area			
		Boring No. 74-62M	Sample No. 4		
		Depth 50.2 - 51.8	Date 9 APR 1975		

CONSOLIDATION TEST REPORT

Figure 4

③



PROJECT: Lake Darling Dam MCS-1A-75-45-MD-F

MRD LABORATORY NO: 74/342 & 75/17

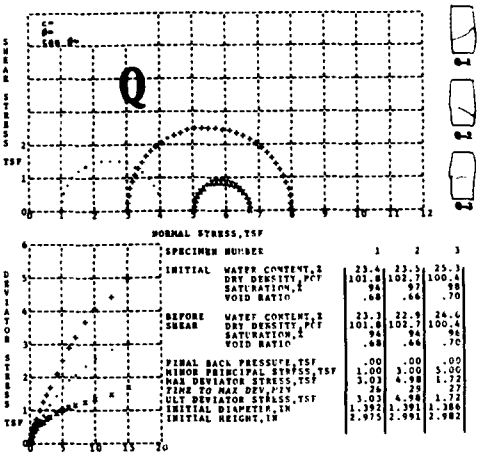
BORING NO: 74-62M SAMPLE NO: 4 DEPTH: 50.2 - 51.8 DATE: 9 APR 1975

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

FIGURE 4a

④



SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT, %	23.4	23.5	25.3
	DRY DENSITY, PCF	101.8	102.7	100.4
	SATURATION, %	94	97	98
	VOID RATIO	.68	.66	.70
BEFORE SHEAR	WATER CONTENT, %	23.3	22.9	26.4
	DRY DENSITY, PCF	101.8	102.7	100.4
	SATURATION, %	94	94	98
	VOID RATIO	.68	.66	.70
FINAL BACK PRESSURE, TSF		.00	.00	.00
MINOR PRINCIPAL STRESS, TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS, TSF		3.03	4.98	1.72
TIME TO MAX DEV, FIFTY		.26	.29	.27
ULT DEVIATOR STRESS, TSF		3.03	4.98	1.72
INITIAL DIAMETER, IN		1.392	1.391	1.386
INITIAL HEIGHT, IN		2.975	2.991	2.982

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Loam clay, CL

LL 36 PL 19 PI 16 Gs= 2.74 TYPE SPECIMEN: UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

Specimen 6-3 was predominantly silt, middle to bottom. Failure occurred at an approx. 40° silt seam within the upper clay material. Gray clay and silt. Some fine sand. Brittle structure, medium consistency. Low toughness at PL, dull shine, fast shaking reaction.

PROJECT: Lake Darling Dam MCS-1A-75-45-MD-F

BORING NO: 74-62M SAMPLE NO: 5

DEPTH: 64.7 - 66.7

MRD LAB NO: 75/17 DATE 30 MAY 1975

TRIAXIAL COMPRESSION TEST REPORT

FIGURE 5

⑧

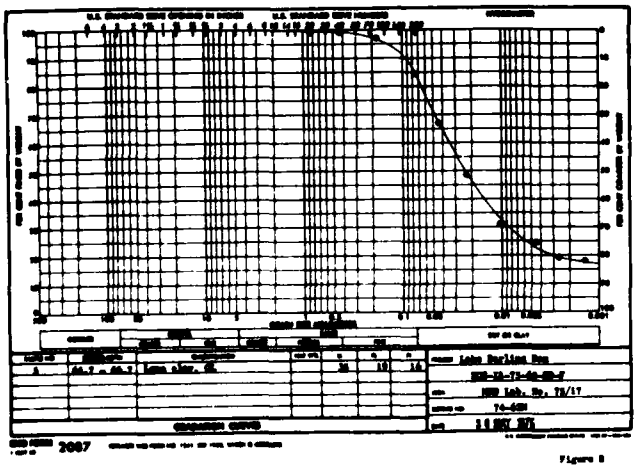


Figure 8

⑦

DESIGN MEMORANDUM NO. 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

SOILS TEST DATA
LAKE DARLING DAM

BORING 74-62 M

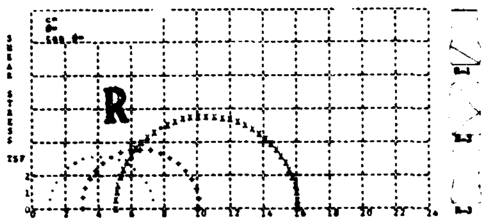
ST PAUL, MINN DISTRICT

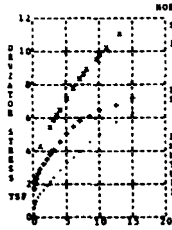
JUNE 1983

RI-R-5/748

PLATE NO. 5-46

CORPS OF ENGINEERS





SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT, %	22.5	22.8	23.6
	DRY DENSITY, PCF	104.8	104.5	103.2
	SATURATION, %	98	98	98
	VOID RATIO	.63	.64	.66
BEFORE SHEAR	WATER CONTENT, %	20.8	20.8	22.3
	DRY DENSITY, PCF	106.5	108.6	110.1
	SATURATION, %	94	99	100+
	VOID RATIO	.61	.57	.55
FINAL BACK PRESSURE, TSF		2.66	1.94	1.94
MINOR PRINCIPAL STRESS, TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS, TSF		6.34	7.17	11.10
TIME TO MAX DEV, MIN		135	125	151
ULT DEVIATOR STRESS, TSF		6.34	7.17	11.10
INITIAL DIAMETER, IN		1.389	1.390	1.391
INITIAL HEIGHT, IN		3.003	2.982	2.998

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Lean clay, CL

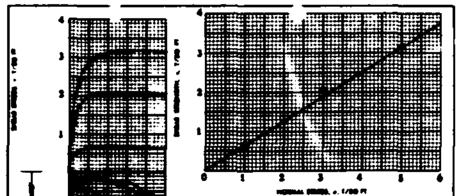
LL 36 PL 19 PI 16 Gs= 2.74 TYPE SPECIMEN: UNDISTURBED TYPE TEST R

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

PROJECT: Lake Darling Dam
NCS-IA-75-60-SD-F
BORING NO: 74-6SM SAMPLE NO: 5
DEPTH: 64.7 - 66.7
NRD LAB NO: 75/17 DATE 30 MAY 1975

TRIAXIAL COMPRESSION TEST REPORT
FIGURE 2

①



[illegible]			1	2	3	
[illegible]	[illegible]		22.8%	21.8%	23.8%	%
	[illegible]		0.80	0.73	0.78	
	[illegible]		78 %	82 %	84 %	%
	[illegible]		95.0	98.7	96.2	
[illegible]			0.79	0.72	0.75	
[illegible]						
[illegible]	[illegible]		23.6%	22.5%	22.5%	%
	[illegible]		0.76	0.68	0.71	
	[illegible]		86 %	90 %	90 %	%
[illegible]			1.0	3.0	5.0	
[illegible]			0.67	2.00	3.10	
[illegible]			470	380	830	
[illegible]	(x10⁻⁴)		5.1	4.4	4.2	
[illegible]			0.66	2.03	3.15	

φ = 32.4°
tan φ = 0.638
c = — [illegible]

TYPE OF SPECIMEN: Undisturbed — 3.0 [illegible] — 0.5 [illegible]

CLASSIFICATION: Lean clay, CL

LL 36 | PL 19 | PI 16 | Gs 2.74

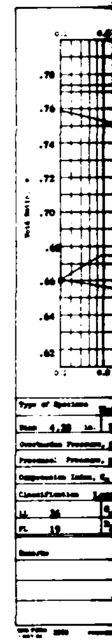
REMARKS

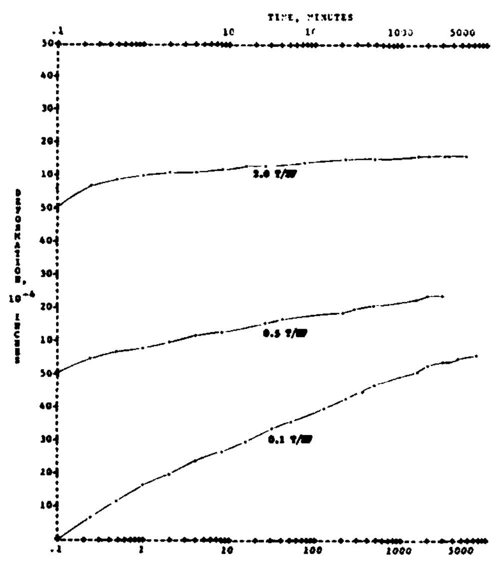
PROJECT: Lake Darling Dam NCS-IA-75-60-SD-F
NRD Lab. No. 75/17
BORING NO. 74-6SM SAMPLE NO. 5
DEPTH 64.7 - 66.7 DATE 30 MAY 1975

DIRECT SHEAR TEST REPORT

ENG FORM 2092 [illegible] (TRANSLUCENT)
Figure 3

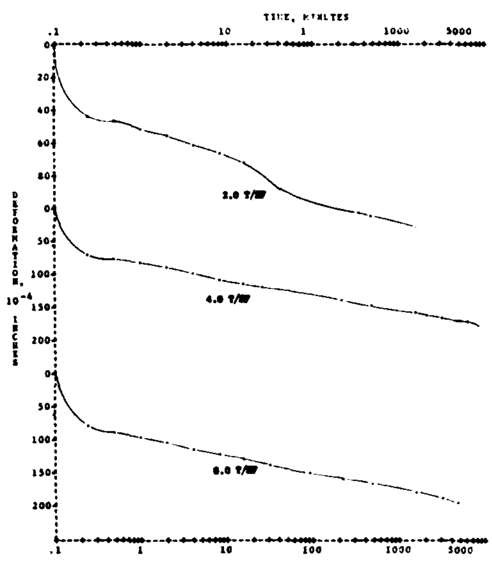
②





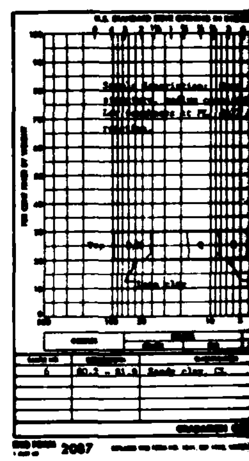
PROJECT: Lake Darling Dam NCS-IA-75-60-SD-F
NRD LABORATORY NO: 75/17
BORING NO: 74-6SM SAMPLE NO: 5 DEPTH: 64.7 - 66.7 DATE: 30 MAY 1975
CONSOLIDATION TEST -- TIME CURVES
MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088 FIGURE 7

⑤



PROJECT: Lake Darling Dam NCS-IA-75-60-SD-F
NRD LABORATORY NO: 75/17
BORING NO: 74-6SM SAMPLE NO: 5 DEPTH: 64.7 - 66.7 DATE: 30 MAY 1975
CONSOLIDATION TEST -- TIME CURVES
MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088 FIGURE 8

⑥



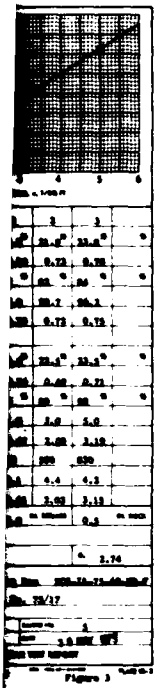


Figure 3

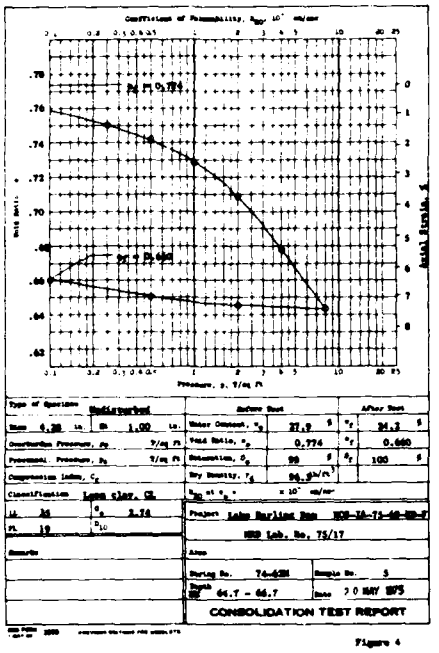
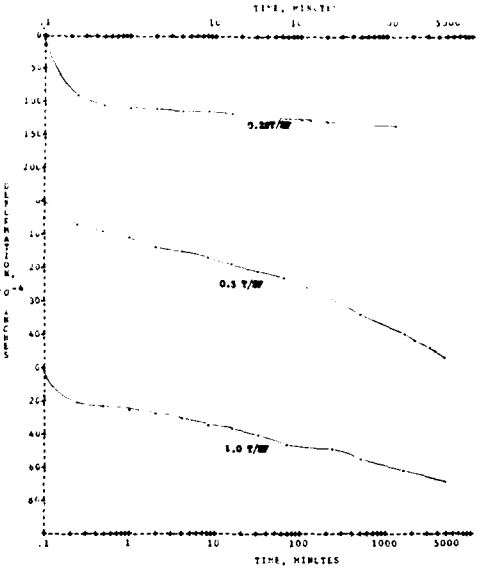


Figure 4

③



PROJECT: Lake Darling Dam NCB-3A-75-60-BB-F

MRD LABORATORY NO: 75/17

BORING NO: 74-62M SAMPLE NO: 5 DEPTH: 64.7 - 66.7 DATE: 30 MAY 1975

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

FIGURE 5

④

1000 5000

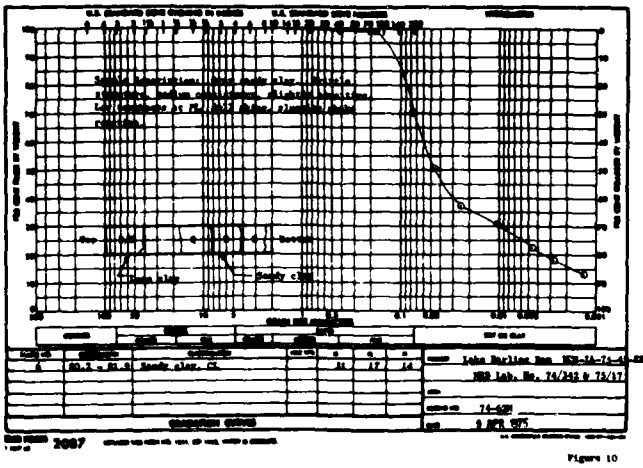
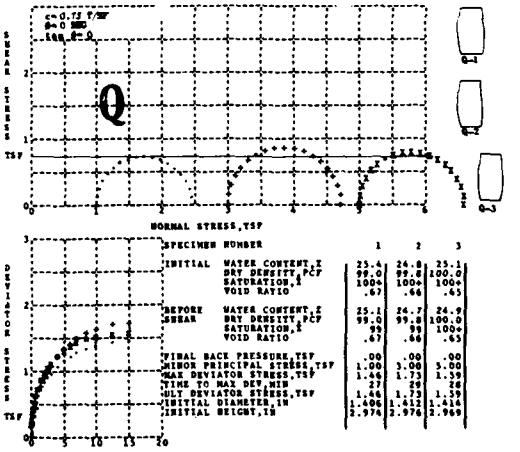


Figure 10

⑦



SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT,%	23.4	24.8	25.1
	DRY DENSITY,PCF	99.0	99.8	100.0
	SATURATION,%	100+	100+	100+
	VOID RATIO	.67	.66	.65
BEFORE SHEAR	WATER CONTENT,%	25.1	24.7	24.9
	DRY DENSITY,PCF	99.0	99.8	100.0
	SATURATION,%	99	98	100+
	VOID RATIO	.67	.66	.65
FINAL BACK PRESSURE,TSF		.00	.00	.00
MINOR PRINCIPAL STRESS,TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS,TSF		1.46	1.73	1.59
TIME TO MAX DEV MIN		27	28	28
ULT DEVIATOR STRESS,TSF		1.46	1.73	1.59
INITIAL DIAMETER,IN		1.406	1.412	1.416
INITIAL HEIGHT,IN		2.974	2.976	2.969

AXIAL STRAIN,%

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

LL 31 PL 17 PI 14 Gs= 2.65 TYPE SPECIMEN: UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

PROJECT: Lake Darling Dam NCB-3A-75-60-BB-F

BORING NO: 74-62M SAMPLE NO: 6

DEPTH: 80.3 - 81.9

MRD LAB NO: 74/343 & 75/17 DATE: 9 APR 1975

TRIAXIAL COMPRESSION TEST REPORT

FIGURE 6

⑧

DESIGN MEMORANDUM NO. 3 GENERAL

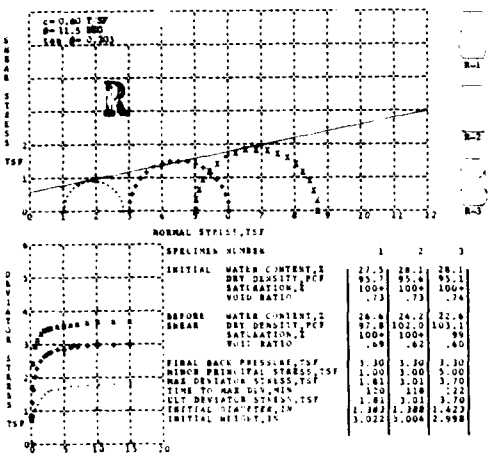
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

SOILS TEST DATA
LAKE DARLING DAM
BORING 74-62 M

ST PAUL, MINN DISTRICT

JUNE 1983

RI-R-8/746 PLATE NO.8-47



SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT, %	27.5	28.1	28.1
	DRY DENSITY, PCF	95.7	95.6	95.1
	SATURATION, %	100+	100+	100+
	VOID RATIO	.73	.73	.74
BEFORE SHEAR	WATER CONTENT, %	26.6	25.2	22.6
	DRY DENSITY, PCF	97.8	102.0	103.1
	SATURATION, %	100+	100+	95
	VOID RATIO	.69	.62	.60
FINAL BACK PRESSURE, TSF		3.30	3.30	3.30
MINOR PRINCIPAL STRESS, TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS, TSF		1.81	3.01	3.70
TIME TO MAX DEV, MIN		120	118	122
ULT DEVIATOR STRESS, TSF		1.81	3.01	3.70
INITIAL DIA/TYPE, IN		1.302	1.288	1.427
INITIAL HEIGHT, IN		3.022	3.004	2.998

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMEN: Sandy clay, CL

LL 31 PL 17 PI 14 Gs= 2.65 TYPE SPECIMEN: UNDISTURBED TYPE TEST R

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2088

PROJECT: Lake Barling Dam MCS-1A-75-45-ED-F

BORING NO: 74-62N SAMPLE NO: 6

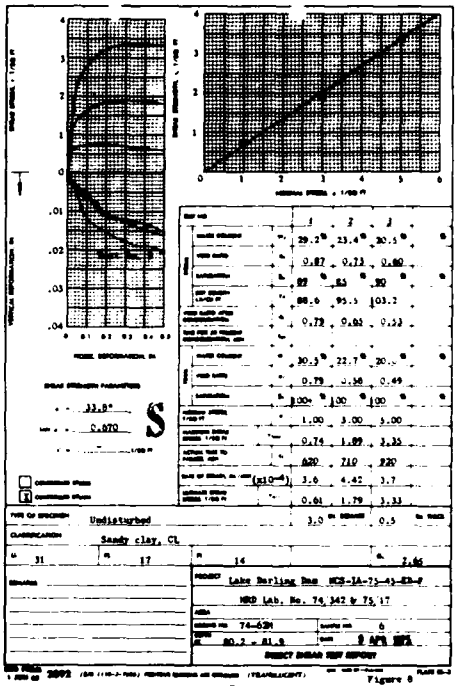
DEPTH: 80.2 - 81.9

MRD LAB NO: 74,342 & 75,17 DATE 8 APR 1975

TRIAXIAL COMPRESSION TEST REPORT

FIGURE 7

①



	1	2	3
	29.2%	23.4%	20.5%
	0.87	0.73	0.60
	97	85	90
	88.6	95.5	103.2
	0.72	0.61	0.53
	30.5%	22.7%	20.2%
	0.79	0.56	0.49
	100+	100	100
	1.00	3.00	5.00
	0.74	1.89	3.35
	820	710	920
	3.6	4.42	3.7
	0.61	1.79	3.33

33.8°

0.670

S

TYPE OF SPECIMEN: Undisturbed — 3.0 in diameter — 0.5 in thick

CLASSIFICATION: Sandy clay, CL

LL 31 PL 17 PI 14 Gs 2.65

PROJECT: Lake Barling Dam MCS-1A-75-45-ED-F

MRD Lab. No. 74,342 & 75,17

BORING NO. 74-62N SAMPLE NO. 6

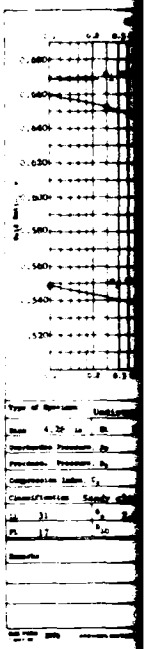
DEPTH 80.2 - 81.9 DATE 8 APR 1975

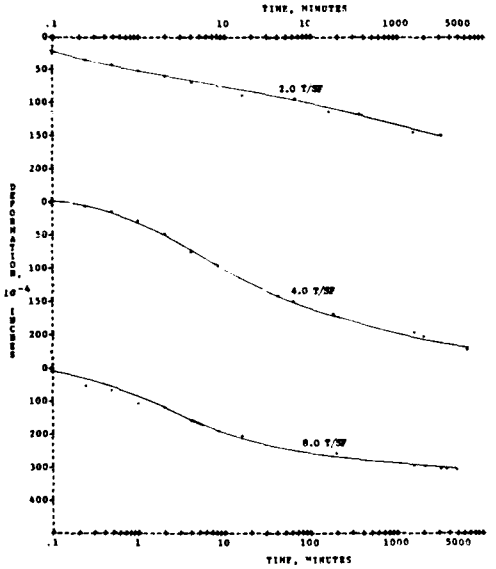
DIRECT SHEAR TEST REPORT

DD FORM 2092

Figure 8

②





PROJECT: Lake Barling Dam MCS-1A-75-45-ED-F

MRD LABORATORY NO: 74/342 & 75/17

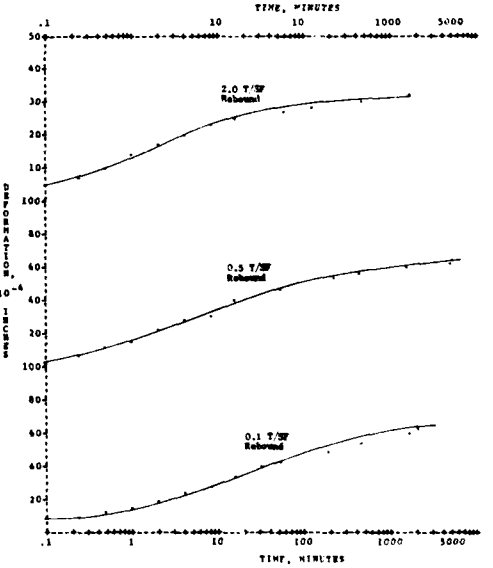
BORING NO: 74-62N SAMPLE NO: 6 DEPTH: 80.2 - 81.9 DATE: 8 APR 1975

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

FIGURE 9b

⑤



PROJECT: Lake Barling Dam MCS-1A-75-45-ED-F

MRD LABORATORY NO: 74/342 & 75/17

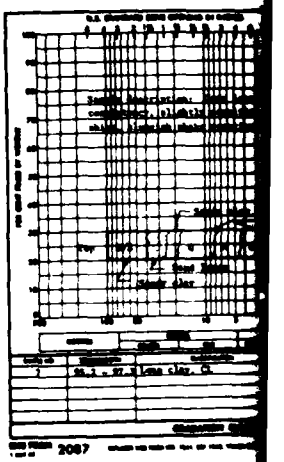
BORING NO: 74-62N SAMPLE NO: 6 DEPTH: 80.2 - 81.9 DATE: 8 APR 1975

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

FIGURE 9c

⑥



DD FORM 2087

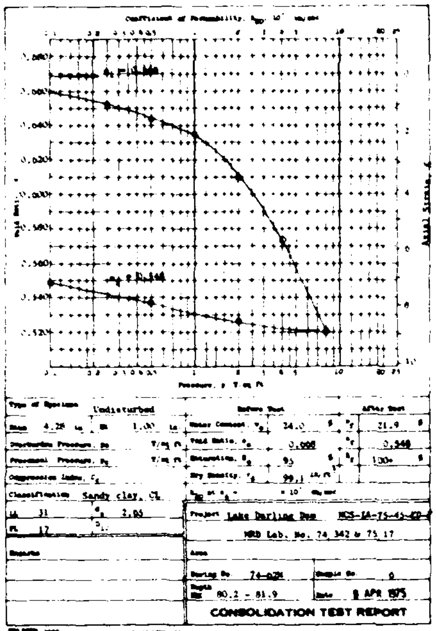
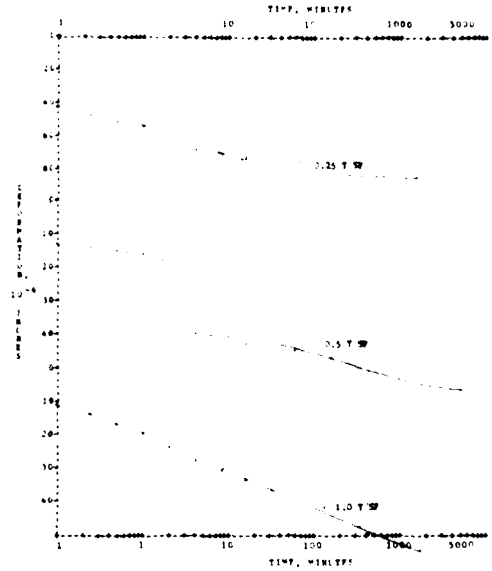


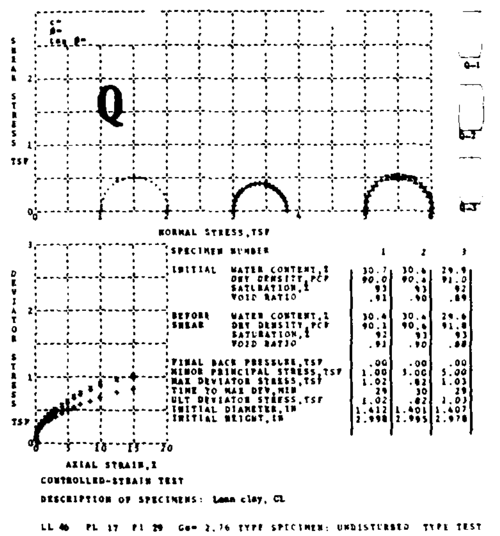
Figure 9

③



PROJECT: Lake Darling Dam NCS-IA-75-45-ED-F
NRD LABORATORY NO: 74 342 & 75 17
BORING NO: 74-62M SAMPLE NO: 6 DEPTH: 80.2 - 81.9 DATE: 8 APR 1975
CONSOLIDATION TEST -- TIME CURVES
MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088 FIGURE 9a

④



PROJECT: Lake Darling Dam NCS-IA-75-45-ED-F
BORING NO: 74-62M SAMPLE NO: 7
DEPTH: 95.2 - 97.3
NRD LAB NO: 74 342 & 75 17 DATE: 8 APR 1975
TRIAXIAL COMPRESSION TEST REPORT
FIGURE 11

⑧

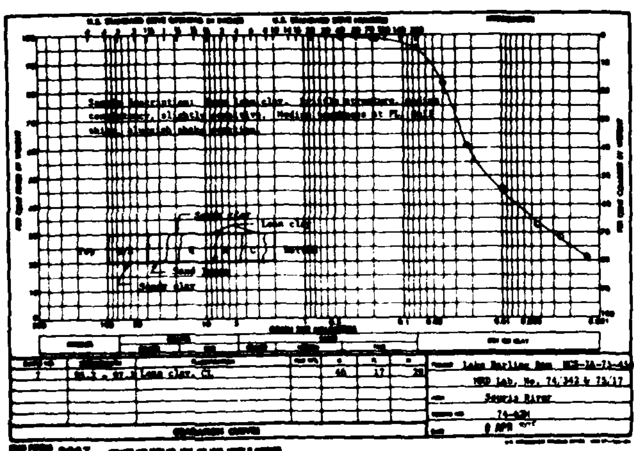


Figure 13

⑦

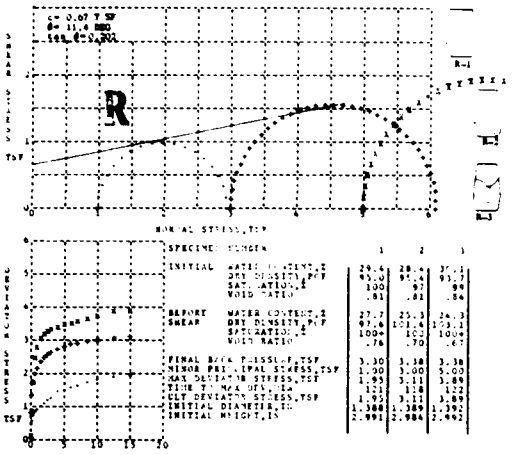
DESIGN MEMORANDUM NO. 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

SOILS TEST DATA
LAKE DARLING DAM

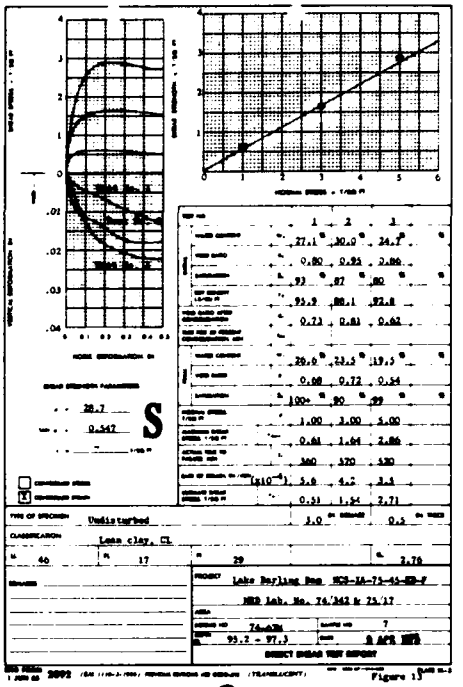
BORING 74-62 M

ST. PAUL, MINN. DISTRICT

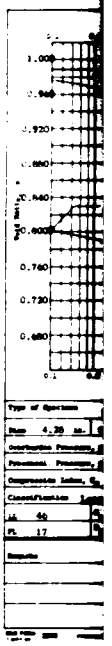
JUNE 1983

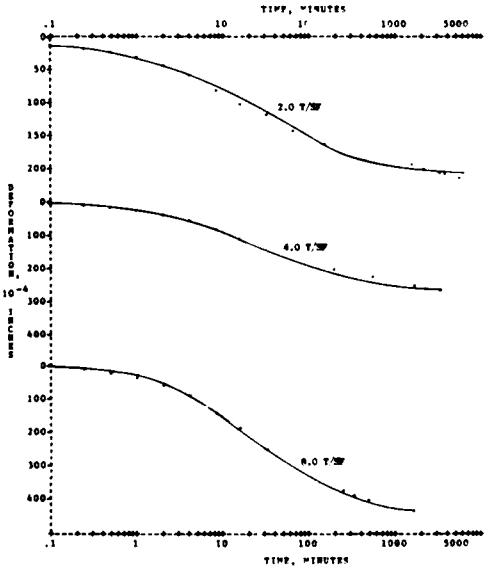

AXIAL STRAIN,%
CONTROLLED-STRAIN TEST
DESCRIPTION OF SPECIMENS: Loam clay, CL
LL 46 PL 17 PI 29 Gs= 2.76 TYPE SPECIMEN: UNDISTURBED TYPE TEST R
REMARKS: MACHINE PRINT OUT FORMAT AFTER E4G FORM 2089
PROJECT: Lake Darling Dam MCS-1A-75-45-ED-F
BORING NO: 74-63N SAMPLE NO: 7
DEPTH: 95.2 - 97.3
MRD LAB NO: 74,342 DATE 9 APR 75
& 75,17
TRIAXIAL COMPRESSION TEST REPORT
PLATE 12

①

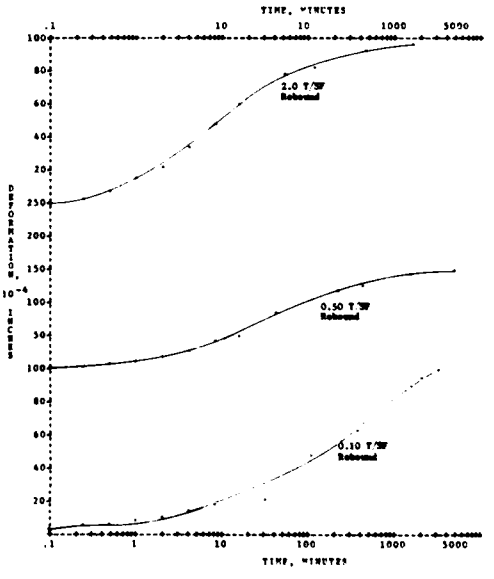

S
Undisturbed
Loam clay, CL
Lake Darling Dam MCS-1A-75-45-ED-F
MRD Lab. No. 74,342 & 75,17
74-63N
95.2 - 97.3
9 APR 75
DIRECT SHEAR TEST REPORT
Figure 13

②

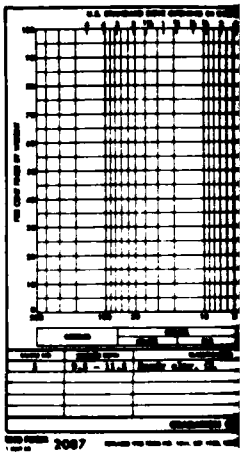



TIME, MINUTES
2.0 T/SF
4.0 T/SF
8.0 T/SF
PROJECT: Lake Darling Dam MCS-1A-75-45-ED-F
MRD LABORATORY NO: 74/342 & 75/17
BORING NO: 74-63N SAMPLE NO: 7 DEPTH: 95.2 - 97.3 DATE: 9 APR 75
CONSOLIDATION TEST -- TIME CURVES
MACHINE PRINT OUT
FORMAT AFTER ERC FORM 2088
PLATE 14b

⑤


TIME, MINUTES
2.0 T/SF Rebound
0.50 T/SF Rebound
0.10 T/SF Rebound
PROJECT: Lake Darling Dam MCS-1A-75-45-ED-F
MRD LABORATORY NO: 74/342 & 75/17
BORING NO: 74-63N SAMPLE NO: 7 DEPTH: 95.2 - 97.3 DATE: 9 APR 75
CONSOLIDATION TEST -- TIME CURVES
MACHINE PRINT OUT
FORMAT AFTER ERC FORM 2088
PLATE 14c

⑥



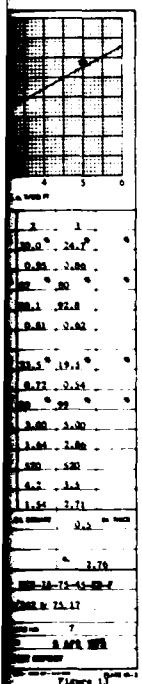


Figure 13

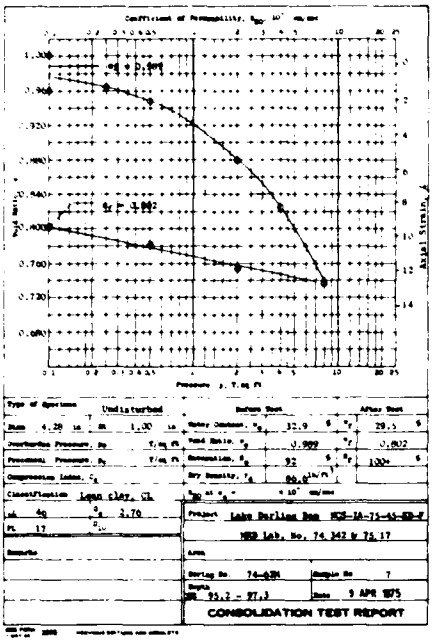
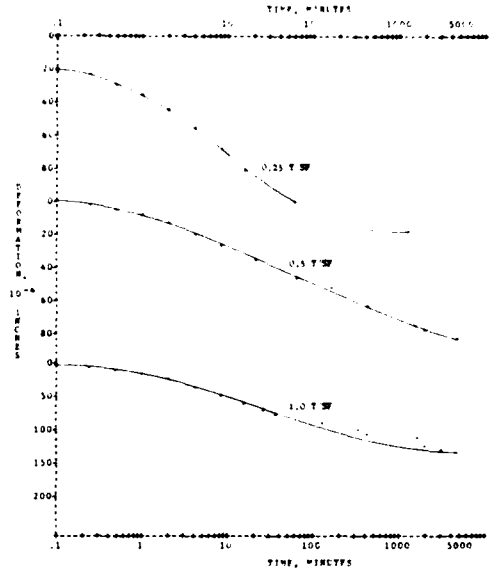


Figure 14

③



PROJECT: Lake Darling Dam MCS-1A-75-45-ED-F

NRD LABORATORY NO: 74-342 & 75-17

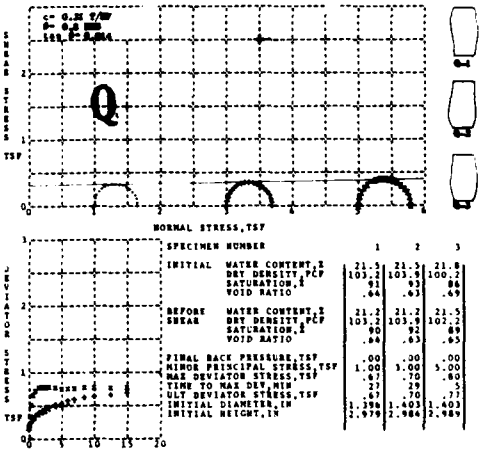
BORING NO: 74-63M SAMPLE NO: 7 DEPTH: 95.2 - 97.3 DATE: 8 APR 1975

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

PICTURE 14a

④



SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT,%	21.3	21.3	21.8
	DRY DENSITY,PCF	103.2	103.9	100.2
	SATURATION,%	91	93	86
	VOID RATIO	.64	.63	.69
BEFORE SHEAR	WATER CONTENT,%	21.2	21.2	21.5
	DRY DENSITY,PCF	103.2	103.9	102.2
	SATURATION,%	90	92	89
	VOID RATIO	.64	.63	.65
FINAL BACK PRESSURE,TSF		.00	.00	.00
MINOR PRINCIPAL STRESS,TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS,TSF		.67	.70	.80
TIME TO MAX DEV,MIN		27	29	3
ULT DEVIATOR STRESS,TSF		.67	.70	.77
INITIAL DIAMETER,IN		1.396	1.403	1.403
INITIAL HEIGHT,IN		2.979	2.984	2.989

AXIAL STRAIN,%

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

LL 30 PL 15 PI 16 Gs= 2.71 TYPE SPECIMEN: UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

Light brown sandy clay, brittle structure, soft consistency, slightly sensitive, medium toughness at PL, dull shine, fast shake reaction.

PROJECT: Lake Darling Dam MCS-1A-75-45-ED-F
Souris River

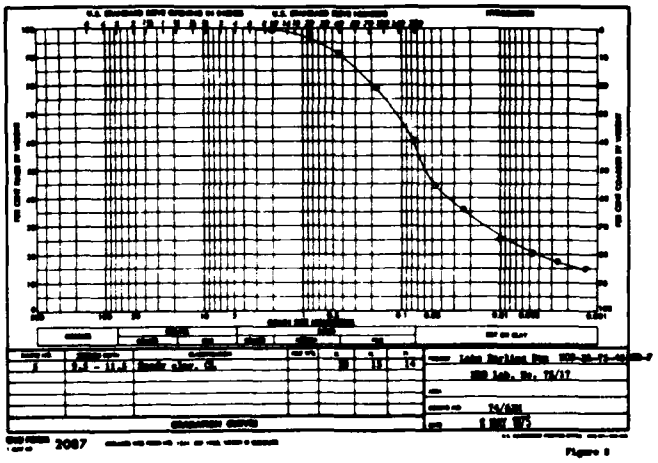
BORING NO: 74-63M SAMPLE NO: 5

DEPTH: 9.8 - 11.5

NRD LAB NO: 74/342 & 75/17 DATE 8 MAY 1975

TRIAXIAL COMPRESSION TEST REPORT
FIGURE 6

⑧



5	9.8 - 11.5	Sandy clay, CL		30	15	16			

Lake Darling Dam MCS-1A-75-45-ED-F
NRD Lab. No. 75/17
74/63M
8 MAY 1975

2087

Figure 6

⑦

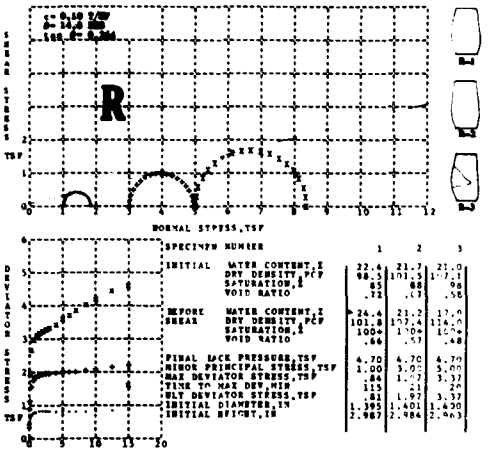
DESIGN MEMORANDUM NO. 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
SOILS TEST DATA
LAKE DARLING DAM
BORINGS 74-62M AND 74-63M

ST PAUL, MINN DISTRICT

JUNE 1983

RI-R-S/748

PLATE NO 8-49



SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT, %	22.6	21.7	21.0
	DRY DENSITY, PCF	98.5	101.5	103.1
	SATURATION, %	85	88	96
	VOID RATIO	.72	.63	.58
BEFORE SHEAR	WATER CONTENT, %	24.4	21.2	17.9
	DRY DENSITY, PCF	101.8	107.4	114.0
	SATURATION, %	100+	100+	100+
	VOID RATIO	.66	.57	.48
FINAL BACK PRESSURE, TSF		4.70	4.70	4.70
MINOR PRINCIPAL STRESS, TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS, TSF		.84	1.07	3.37
TIME TO MAX DEV, MIN		115	11	20
ULT DEVIATOR STRESS, TSF		.81	1.97	3.37
INITIAL DIAMETER, IN		1.395	1.401	1.400
INITIAL HEIGHT, IN		2.987	2.984	2.983

AXIAL STRAIN, %

CONTROLLED-STRAIN TEST

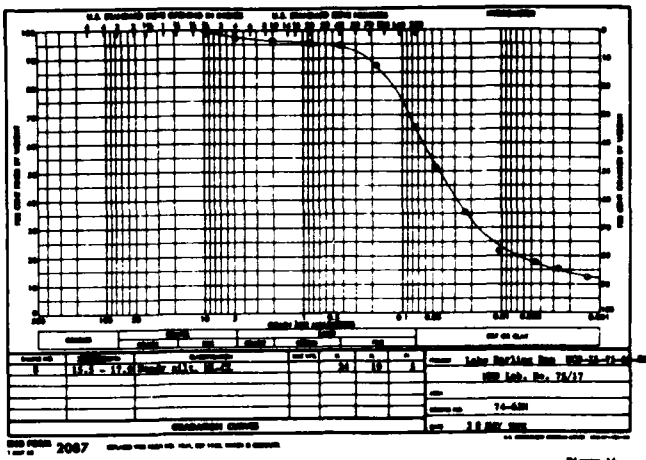
DESCRIPTION OF SPECIMENS: Sandy clay, CL

LL 29 PL 18 PI 16 Gs= 2.71 TYPE SPECIMEN: UNDISTURBED TYPE TEST R

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

PROJECT: Lake Sterling Dam HDR-55-73-60-
Scenic River 55-7
BORING NO: 74-42H SAMPLE NO: 5
DEPTH: 9.5 - 11.5
MRD LAI NO: 74/43 DATE 9 MAY 1975
75/17
TRIAXIAL COMPRESSION TEST REPORT
PICKET 7

①



1	15.5 - 17.0 Sandy silt, SM-ML	34	19	8

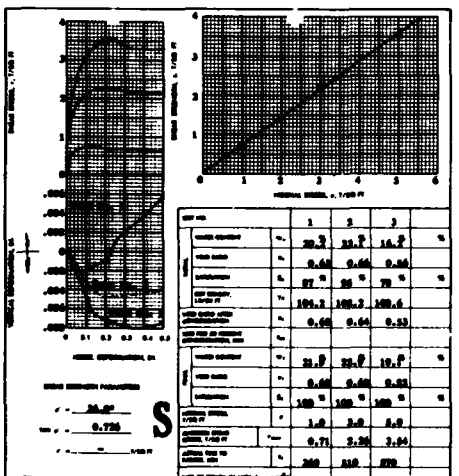
Lake Sterling Dam HDR-55-73-60-55-7
MRD Lab. No. 75/17
Area
Boring no. 74-42H Sample no. 5
Depth 15.5 - 17.0 Date 16 MAY 1975

ENGINEER DESIGN

ENG FORM 2087 1 SEP 60

Figure 16

②



	1	2	3	
Water Content, %	20.2	21.7	16.2	%
Void Ratio, e	0.66	0.66	0.46	
Saturation, %	87	89	78	%
Dry Density, Lb/cu ft	104.2	103.2	109.6	
Void Ratio after consolidation, e	0.66	0.64	0.53	
Water Content, %	21.9	22.0	19.7	%
Void Ratio, e	0.66	0.66	0.53	
Saturation, %	100 %	100 %	100 %	%
Actual Vertical Stress, TSF	1.0	3.0	5.0	
Actual Back Pressure, TSF	0.71	2.36	3.84	
Actual Vertical Stress, Lb/sq ft	200	600	1000	
Date of Shear, 24 hr clock	4.0	4.4	4.2	
Actual Back Pressure, Lb/sq ft	0.66	2.12	3.36	

Type of Specimen: Undisturbed
Classification: Sandy silt, SM-ML
LL 26 PL 19 PI 8 Gs 2.72

Remarks: Vertical deformation data not recorded for Test No. 2 due to test equipment malfunction.

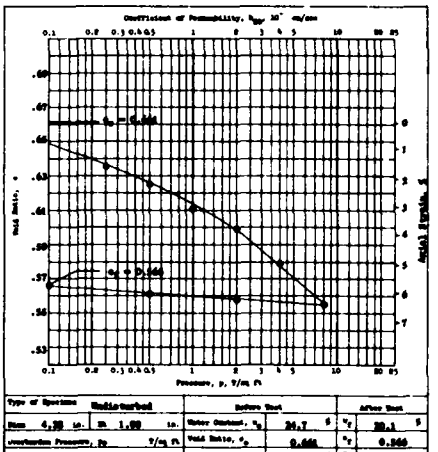
Lake Sterling Dam HDR-55-73-60-55-7
MRD Lab. No. 75/17
Area
Boring no. 74-42H Sample no. 5
Depth 15.5 - 17.0 Date 16 MAY 1975

ENGINEER DESIGN TEST REPORT

ENG FORM 2090 1 SEP 60 FOR (110-3-1400) (CORPS AGENCY OR DIVISION) (TRANSMITTAL)

Figure 11

⑤



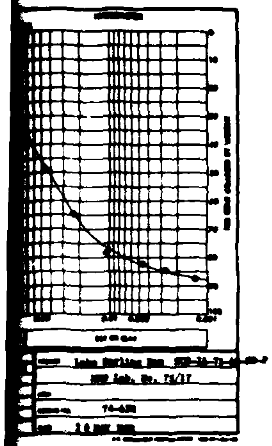
Type of Specimen: Undisturbed	Before Test	After Test
Diam 4.00 in. Ht 1.00 in.	Water Content, w_o 24.7 %	w_f 20.1 %
Consolidation Pressure, p_c T/sq ft	Void Ratio, e_o 0.666	e_f 0.540
Permeant. Pressure, p_p T/sq ft	Saturation, S_o 100+ %	S_f 97 %
Compression Index, C_c	Dry Density, γ_d L_b/ft^3	
Classification: Sandy silt, SM-ML	k_{20} at e_o = $\times 10^{-}$ cm/sec	
LL 26 PL 19 PI 8	G_s 2.72	

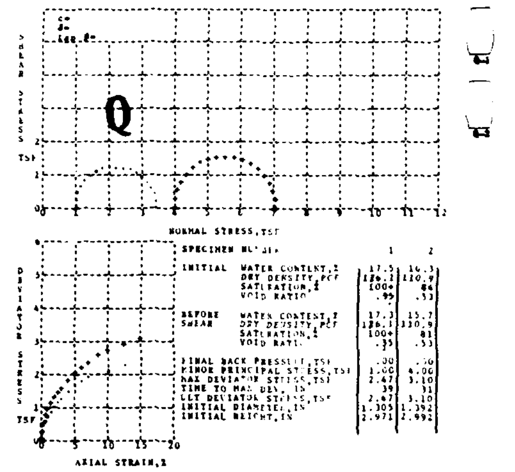
Project: Lake Sterling Dam HDR-55-73-60-55-7
MRD Lab. No. 75/17
Area
Boring No. 74-42H Sample No. 5
Depth 15.5 - 17.0 Date 16 MAY 1975

CONSOLIDATION TEST REPORT

Figure 12

⑥





SPECIMEN NUMBER		1	2
INITIAL	WATER CONTENT,%	17.5	16.3
	DRY DENSITY,PCF	126.1	110.9
	SATURATION,%	100+	86
	VOID RATIO	.35	.53
BEFORE SHEAR	WATER CONTENT,%	17.3	15.7
	DRY DENSITY,PCF	126.1	110.9
	SATURATION,%	100+	81
	VOID RATIO	.35	.53
FINAL BACK PRESSURE,TSF		.00	.00
MINOR PRINCIPAL STRESS,TSF		1.00	4.00
MAX DEVIATOR STRESS,TSF		2.47	3.10
TIME TO MAX DEV, IN		39	31
ULT DEVIATOR STRESS,TSF		2.47	3.10
INITIAL DIAMETER,IN		1.305	1.392
INITIAL HEIGHT,IN		2.971	2.992

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy silt, ML-CL

LL 24 PL 19 PI 5 Gs= 2.72 TYPE SPECIMEN: UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2089

Difficulty in sample trimming; unable to trim third test specimen. Mottled grey to tan clayey sand and silt. Numerous fine gravel sizes. Brittle structure, soft consistency, insensitive. Low toughness at PL, no shine, fast shake reaction.

PROJECT: Lake Darling Dam HCB-2A-73-60-ED-F

BORING NO: 74-63M SAMPLE NO: 8

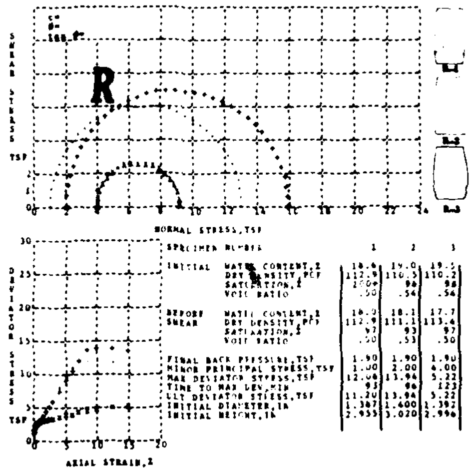
DEPTH: 15.5 - 17.9

NRD LAB NO: 75/17 DATE 30 MAY 1975

TRIAXIAL COMPRESSION TEST REPORT

FIGURE 9

(3)



SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT,%	18.6	19.0	19.5
	DRY DENSITY,PCF	112.9	110.5	110.2
	SATURATION,%	100+	94	94
	VOID RATIO	.50	.54	.54
BEFORE SHEAR	WATER CONTENT,%	16.0	18.1	17.7
	DRY DENSITY,PCF	112.9	111.1	113.4
	SATURATION,%	97	93	97
	VOID RATIO	.50	.53	.50
FINAL BACK PRESSURE,TSF		1.90	1.90	1.90
MINOR PRINCIPAL STRESS,TSF		1.00	2.00	4.00
MAX DEVIATOR STRESS,TSF		12.06	13.94	5.22
TIME TO MAX DEV,MIN		93	96	123
ULT DEVIATOR STRESS,TSF		11.20	13.94	5.22
INITIAL DIAMETER,IN		1.367	1.400	1.392
INITIAL HEIGHT,IN		2.955	3.020	2.996

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy silt, ML-CL

LL 24 PL 19 PI 5 Gs= 2.72 TYPE SPECIMEN: UNDISTURBED TYPE TEST R

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2089

PROJECT: Lake Darling Dam HCB-2A-73-60-ED-F

BORING NO: 74-63M SAMPLE NO: 8

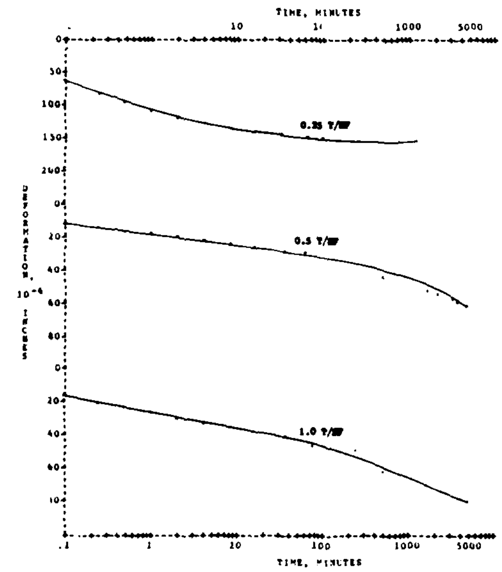
DEPTH: 15.5 - 17.9

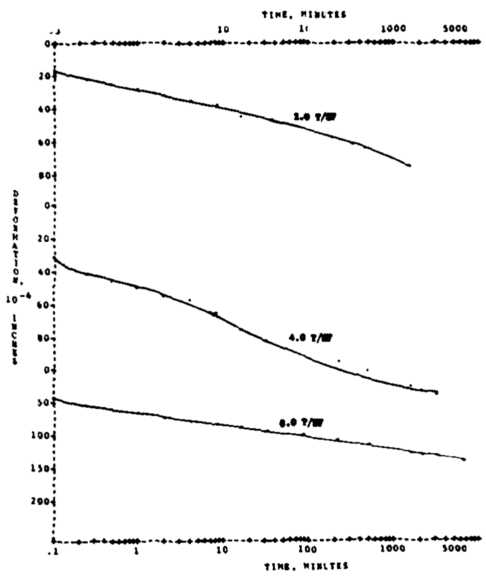
NRD LAB NO: 75/17 DATE 30 MAY 1975

TRIAXIAL COMPRESSION TEST REPORT

FIGURE 10

(4)





PROJECT: Lake Darling Dam HCB-2A-73-60-ED-F

NRD LABORATORY NO: 75/17

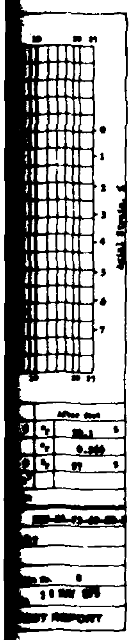
BORING NO: 74-63M SAMPLE NO: 8 DEPTH: 15.5 - 17.9 DATE: 30 MAY 1975

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT FORMAT AFTER ENG FORM 2088

FIGURE 14

(8)



PROJECT: Lake Darling Dam HCB-2A-73-60-ED-F

NRD LABORATORY NO: 75/17

BORING NO: 74-63M SAMPLE NO: 8 DEPTH: 15.5 - 17.9 DATE: 30 MAY 1975

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT FORMAT AFTER ENG FORM 2088

FIGURE 13

(7)

DESIGN MEMORANDUM NO. 3 GENERAL

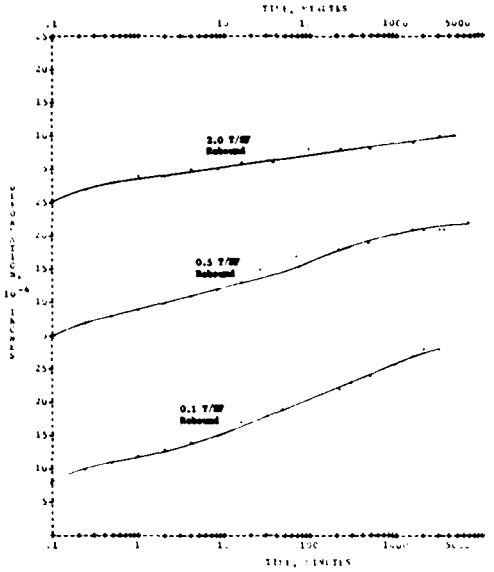
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

SOILS TEST DATA
LAKE DARLING DAM

BORING 74-63 M

ST PAUL, MINN DISTRICT

JUNE 1983



PROJECT: Lake Darling Dam NCS-SA-75-40-ED-F

MRD LABORATORY NO: 75/17

BORING NO: 74-LDM SAMPLE NO: 8 DEPTH: 15.5 - 17.0 DATE: 30 MAY 1975

CONSOLIDATION - TIME -- TYPE OF TEST

MACHINE PRINT OUT FORMAT AFTER ENG FORM ... FILE 15

①

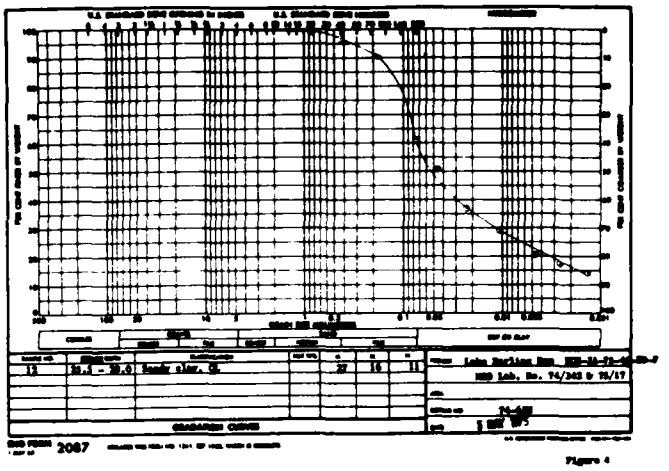
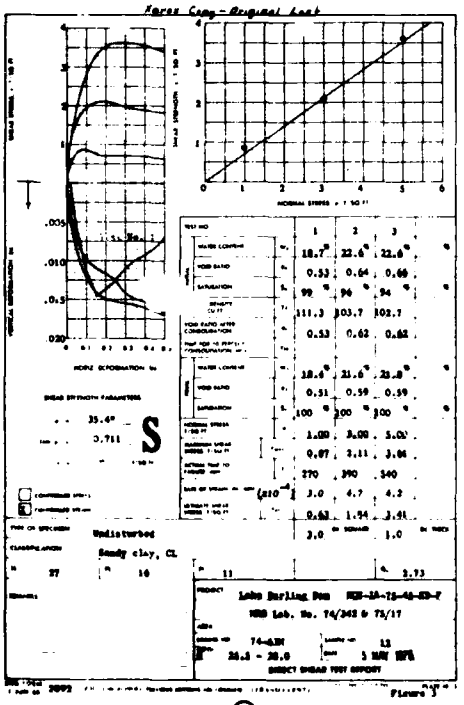


Figure 4

②



⑤

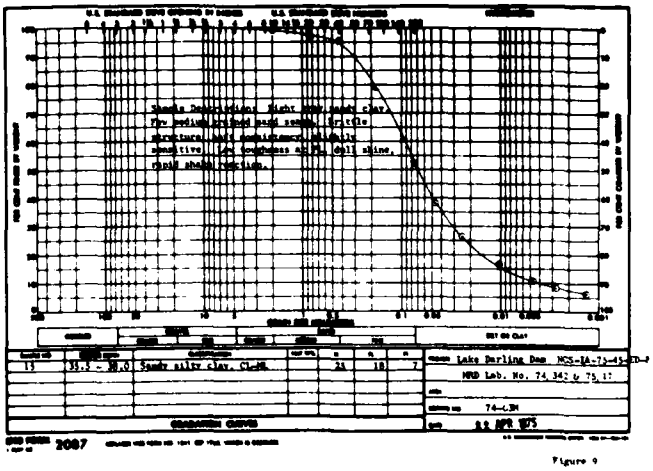


Figure 9

⑤

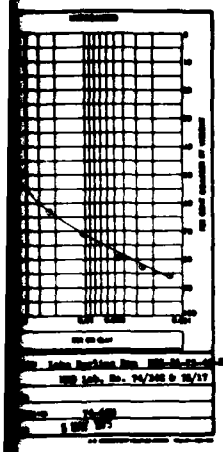
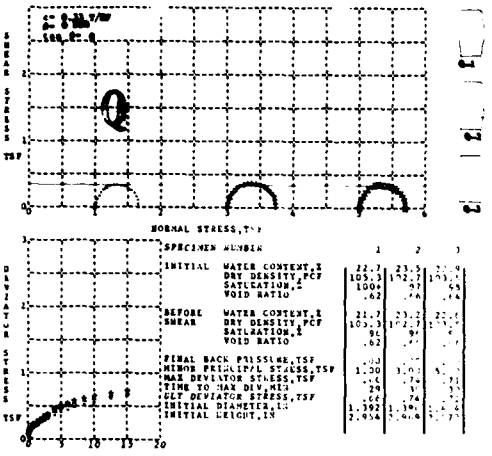


Figure 6



SPECIMEN NUMBER			1	2	3
INITIAL	WATER CONTENT, %		22.7	23.3	23.6
	DRY DENSITY, PCF		105.3	102.7	103.1
	SATURATION, %		100+	97	95
	VOID RATIO		.62	.64	.64
BEFORE SHEAR	WATER CONTENT, %		23.7	23.2	22.5
	DRY DENSITY, PCF		103.3	102.7	104.1
	SATURATION, %		96	94	93
	VOID RATIO		.62	.64	.61
FINAL BACK PRESSURE, TSF			.00	.00	.00
MINOR PRINCIPAL STRESS, TSF			1.30	3.00	5.00
MAX DEVIATOR STRESS, TSF			.76	1.74	3.11
TIME TO MAX DEV, MIN			29	31	33
ULT DEVIATOR STRESS, TSF			.66	1.74	3.11
INITIAL DIAMETER, IN			1.392	1.394	1.406
INITIAL HEIGHT, IN			2.954	2.964	2.974

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

LL 27 PL 16 PI 11 Gs= 2.73 TYPE SPECIMEN: UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

Brown sandy clay, brittle structure, soft consistency, slightly cemtitious, high toughness at PL, gloss shine, slow shake reaction.

PROJECT: Lake Darling Dam MRS-3A-75-45-KB-F
Souris River

BORING NO: 74-63M SAMPLE NO: 12

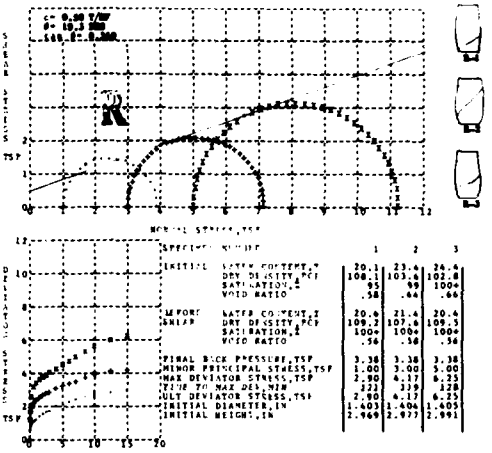
DEPTH: 28.5 - 30.0

MRD LAB NO: 74/342 & 75/17 DATE 5 MAY 1975

TRIAXIAL COMPRESSION TEST REPORT

PLATE 1

③



SPECIMEN NUMBER			1	2	3
INITIAL	WATER CONTENT, %		20.1	23.4	24.4
	DRY DENSITY, PCF		108.1	103.6	102.8
	SATURATION, %		95	99	100+
	VOID RATIO		.58	.64	.66
BEFORE SHEAR	WATER CONTENT, %		20.6	21.4	20.4
	DRY DENSITY, PCF		109.2	107.6	109.5
	SATURATION, %		100+	100+	100+
	VOID RATIO		.56	.58	.56
FINAL BACK PRESSURE, TSF			3.38	3.38	3.38
MINOR PRINCIPAL STRESS, TSF			1.00	3.00	5.00
MAX DEVIATOR STRESS, TSF			2.90	6.17	6.25
TIME TO MAX DEV, MIN			322	329	128
ULT DEVIATOR STRESS, TSF			2.90	6.17	6.25
INITIAL DIAMETER, IN			1.403	1.404	1.405
INITIAL HEIGHT, IN			2.969	2.977	2.991

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

LL 27 PL 16 PI 11 Gs= 2.73 TYPE SPECIMEN: UNDISTURBED TYPE TEST R

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

PROJECT: Lake Darling MRS-3A-75-45-KB-F

BORING NO: 74-63M SAMPLE NO: 12

DEPTH: 28.5 - 30.0

MRD LAB NO: 74/342 & 75/17 DATE 5 MAY 1975

TRIAXIAL COMPRESSION TEST REPORT

PLATE 2

④

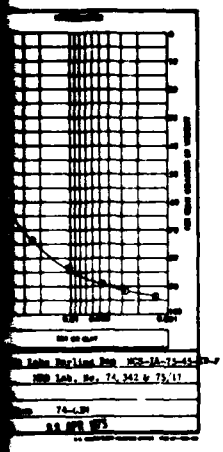
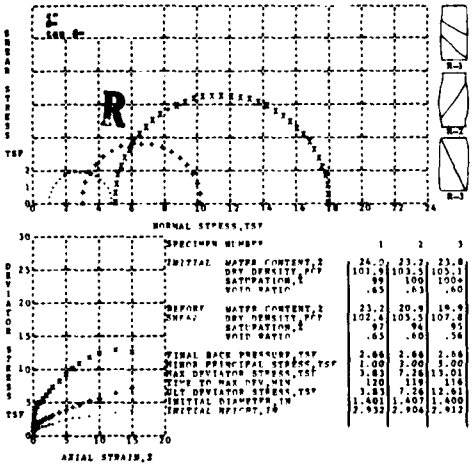


Figure 9



SPECIMEN NUMBER			1	2	3
INITIAL	WATER CONTENT, %		24.0	23.2	23.6
	DRY DENSITY, PCF		101.6	103.5	103.1
	SATURATION, %		99	100	100+
	VOID RATIO		.65	.63	.64
BEFORE SHEAR	WATER CONTENT, %		23.2	20.9	19.9
	DRY DENSITY, PCF		102.4	105.5	107.8
	SATURATION, %		97	96	95
	VOID RATIO		.65	.60	.56
FINAL BACK PRESSURE, TSF			2.66	2.66	2.66
MINOR PRINCIPAL STRESS, TSF			1.00	3.00	5.00
MAX DEVIATOR STRESS, TSF			3.83	7.26	13.01
TIME TO MAX DEV, MIN			120	119	116
ULT DEVIATOR STRESS, TSF			3.83	7.26	12.61
INITIAL DIAMETER, IN			1.401	1.407	1.400
INITIAL HEIGHT, IN			2.932	2.906	2.912

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy, silty clay, CL-ML

LL 25 PL 18 PI 7 Gs= 2.70 TYPE SPECIMEN: UNDISTURBED TYPE TEST R

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

PROJECT: Lake Darling Dam MRS-3A-75-45-KB-F

BORING NO: 74-63M SAMPLE NO: 15

DEPTH: 35.5 - 38.0

MRD LAB NO: 74,342 & 75'17 DATE 22 APR 1975

TRIAXIAL COMPRESSION TEST REPORT

PLATE 7

⑦

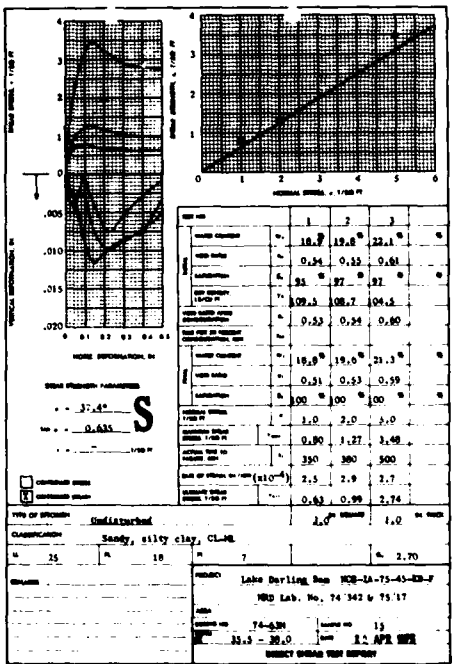


Figure 8

⑧

DESIGN MEMORANDUM NO. 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

SOILS TEST DATA
LAKE DARLING DAM

BORING 74-63M

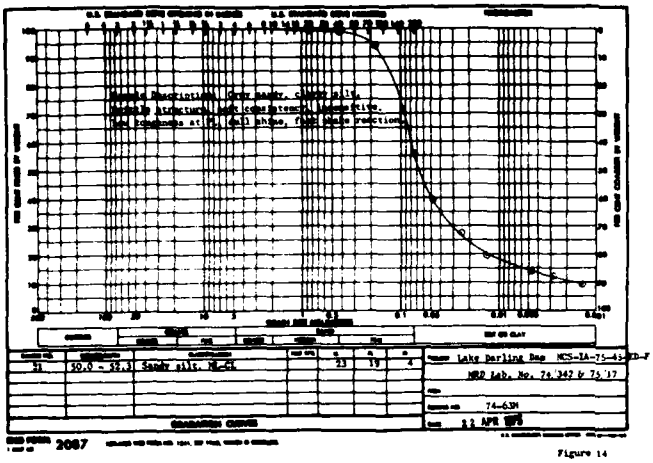
ST PAUL, MINN DISTRICT

JUNE 1983

RI-R-8/780

PLATE NO.8-51

1 2



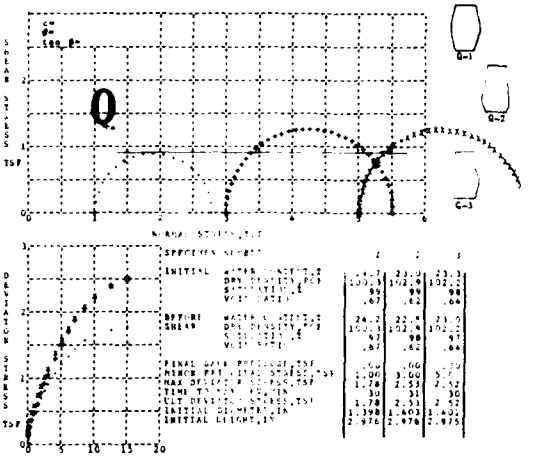
21	50.0 - 52.3	Sandy silt, ML-CL		23	19	4

Project: Lake Darling Dam MCS-IA-75-43-ED-F
NRD Lab. No. 74/342 & 75/17
Boring No. 74-63M
Sample No. 21
Date: 22 APR 1975

Figure 14

2087

①



AXIAL STRAIN, ε

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMEN: Sandy silt, ML-CL

LL 23 PL 19 PI 4 Gs= 2.68 TYPE SPECIMEN: UNDISTURBED TYPE TEST: Q

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

②

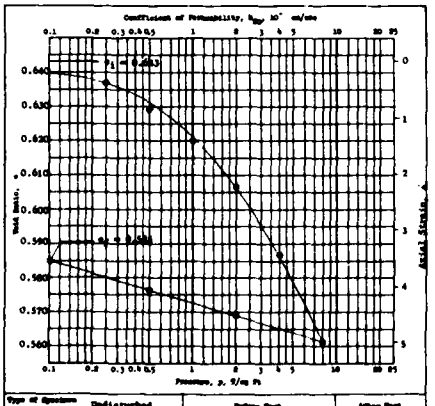
PROJECT: Lake Darling Dam MCS-IA-75-43-ED-F

BORING NO: 74-63M SAMPLE NO 21

DEPTH: 50.0 - 52.3

NRD LAB NO: 74/342, 75/17 DATE 22 APR 1975

TRIAXIAL COMPRESSION TEST REPORT

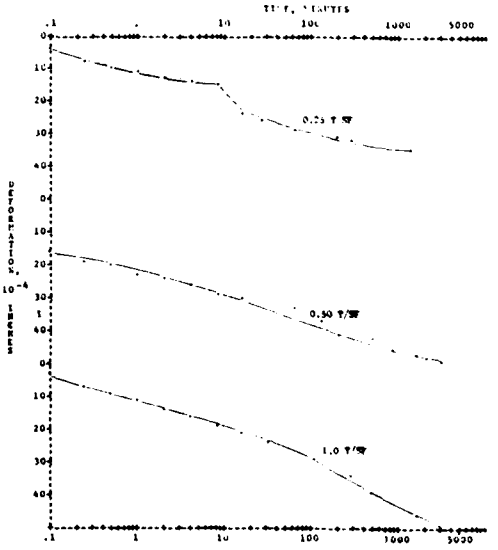


Type of Specimen	Undisturbed	Before Test		After Test	
Diam. 4.38 in.	Ht 1.00 in.	Water Content, w_o	28.2 %	w_f	22.1 %
Confining Pressure, σ_3	T/sq ft	Void Ratio, e_o	0.843	e_f	0.684
Preconsol. Pressure, p_c	T/sq ft	Saturation, S_o	89 %	S_f	100± %
Compression Index, C_c		Dry Density, γ_d	101.6 lb/ft³		
Classification Sandy silt, ML-CL		k_{20} at e_o = x 10⁻⁴ cm/sec			
LL 23	G_s 2.68	Project Lake Darling Dam MCS-IA-75-43-ED-F			
PL 19	k_{20}	NRD Lab. No. 74/342 & 75/17			
Remarks		Area			
		Boring No. 74-63M	Sample No. 21		
		Depth 50.0 - 52.3	Date 22 APR 1975		

CONSOLIDATION TEST REPORT

Figure 13

⑤



TIME, MINUTES

0.25 T/SF

0.50 T/SF

1.0 T/SF

PROJECT: Lake Darling Dam MCS-IA-75-43-ED-F

NRD LABORATORY NO: 74/342 & 75/17

BORING NO: 74-63M SAMPLE NO: 21 DEPTH: 50.0 - 52.3 DATE: 22 APR 1975

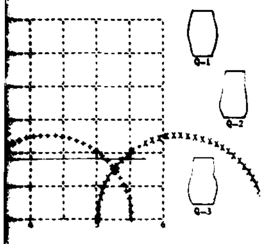
CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

TEST: T 13b

⑥

E F G H J



	1	2	3
...TENT,%	24.7	23.0	23.3
...ITY,PCF	100.3	102.9	102.2
...ON,%	99	99	98
...IO	.67	.62	.64
...TENT,%	24.2	22.8	23.0
...ITY,PCF	100.3	102.9	102.2
...ON,%	97	98	97
...IO	.67	.62	.64
...E,TSF	.00	.00	.00
...RESS,TSF	1.00	3.00	5.00
...S,TSF	1.78	2.53	2.52
...IN	30	31	30
...S,TSF	1.78	2.53	2.52
...IN	1.398	1.403	1.402
...	2.976	2.976	2.975

...CL

...ECIMEN: UNDISTURBED TYPE TEST Q

PROJECT: Lake Darling Dam NCS-IA-75-45-ED-F

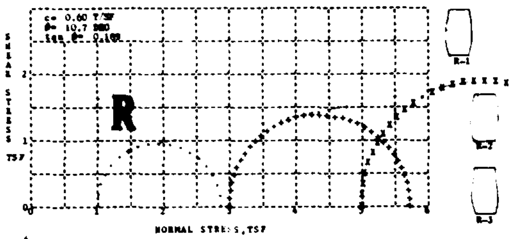
BORING NO: 74-63M SAMPLE NO: 21

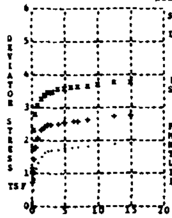
DEPTH: 50.0 - 52.3

MRD LAB NO: 74/342 & 75/17 DATE 22 APR 1975

TRIAXIAL COMPRESSION TEST REPORT

FIGURE 10





SPECIMEN NUMBER		1	2	
INITIAL	WATER CONTENT,%	25.3	24.7	26.5
	DRY DENSITY,PCF	98.1	97.8	96.0
	SATURATION,%	96	93	96
	VOID RATIO	.70	.71	.74
BEFORE SHEAR	WATER CONTENT,%	25.8	25.6	24.0
	DRY DENSITY,PCF	100.0	103.0	104.0
	SATURATION,%	100+	100+	100+
	VOID RATIO	.67	.62	.61
FINAL BACK PRESSURE,TSF		5.40	5.40	5.40
MINOR PRINCIPAL STRESS,TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS,TSF		1.88	2.74	3.77
TIME TO MAX DEV,MIN		121	117	123
ULT DEVIATOR STRESS,TSF		1.88	2.74	3.77
INITIAL DIAMETER,IN		1.391	1.391	1.390
INITIAL HEIGHT,IN		2.985	2.982	2.984

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy silt, ML-CL

LL 23 PL 19 PI 4 Gs= 2.68 TYPE SPECIMEN: UNDISTURBED TYPE TEST R

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

PROJECT: Lake Darling Dam NCS-IA-75-45-ED-F

BORING NO: 74-63M SAMPLE NO: 21

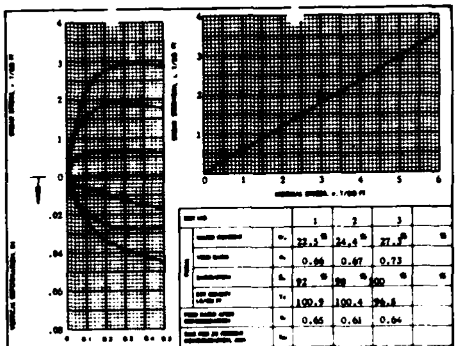
DEPTH: 50.0 - 52.3

MRD LAB NO: 74/342 & 75/17 DATE 22 APR 1975

TRIAXIAL COMPRESSION TEST REPORT

FIGURE 11

③



[illegible]		1	2	3	
[illegible]		22.5 %	24.4 %	27.3 %	%
[illegible]		0.66	0.67	0.73	
[illegible]		92 %	98 %	100 %	%
[illegible]		100.9	100.4	96.8	
[illegible]		0.65	0.61	0.64	
[illegible]					
[illegible]		23.8 %	21.1 %	21.1 %	%
[illegible]		0.62	0.57	0.57	
[illegible]		100+ %	100 %	100 %	%
[illegible]		1.00	3.00	5.00	
[illegible]		0.64	1.91	2.92	
[illegible]		500	440	680	
[illegible]	(x10⁻⁴)	4.2	5.3	4.0	
[illegible]		0.60	1.77	2.88	

Undisturbed 3.0 1.0

Sandy silt, ML-CL

23 19 4 2.68

ϕ = 30.2° tan ϕ = 0.584

PROJECT Lake Darling Dam NCS-IA-75-45-ED-F

MRD Lab. No. 74/342 & 75/17

BORING NO. 74-63M SAMPLE NO. 21

DEPTH 50.0 - 52.3 DATE 22 APR 1975

DIRECT SHEAR TEST REPORT

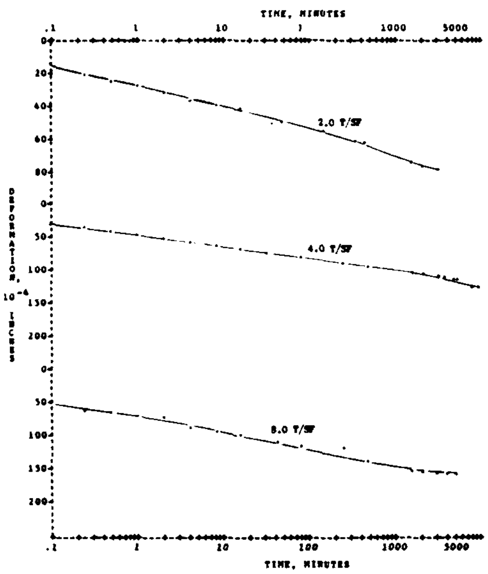
Figure 12

④

...30.3 DATE: 22 APR 1975

...CURVES

FIGURE 13a



PROJECT: Lake Darling Dam NCS-IA-75-45-ED-F

MRD LABORATORY NO: 74/342 & 75/17

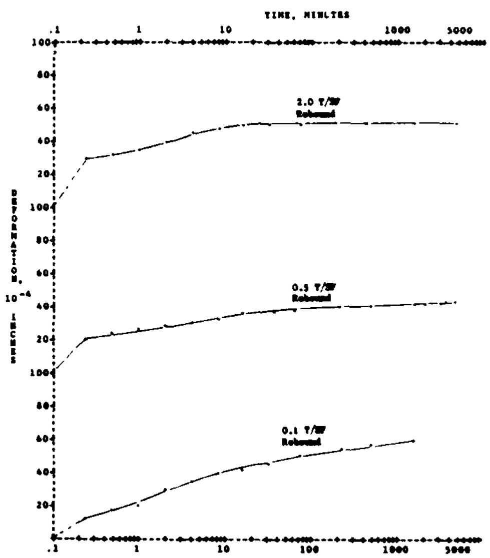
BORING NO: 74-63M SAMPLE NO: 21 DEPTH: 50.0 - 52.3 DATE: 22 APR 1975

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

FIGURE 13b

⑦



PROJECT: Lake Darling Dam NCS-IA-75-45-ED-F

MRD LABORATORY NO: 74/342 & 75/17

BORING NO: 74-63M SAMPLE NO: 21 DEPTH: 50.0 - 52.3 DATE: 22 APR 1975

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

FIGURE 13c

⑧

DESIGN MEMORANDUM NO. 5 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

SOILS TEST DATA
LAKE DARLING DAM
BORING 74-63 M

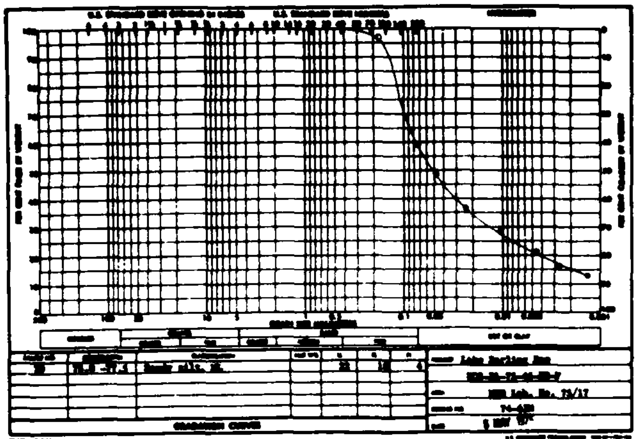
ST PAUL, MINN DISTRICT

APR 1980

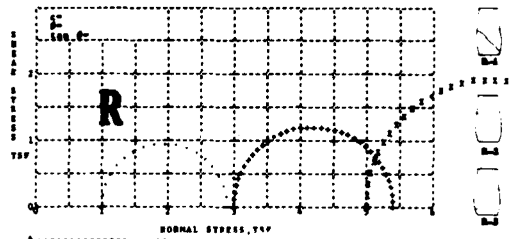
RI-R-5/751 PLATE NO. B-82

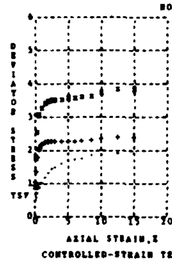
1 2

CORPS OF ENGINEERS



①





SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT,%	25.3	25.6	25.3
	DRY DENSITY,PCF	100.4	99.1	100.1
	SATURATION,%	96	94	96
	VOID RATIO	.73	.76	.74
BEFORE SHEAR	WATER CONTENT,%	23.1	23.2	21.2
	DRY DENSITY,PCF	101.6	102.2	106.6
	SATURATION,%	90	92	93
	VOID RATIO	.71	.70	.63
FINAL BACK PRESSURE,TSF		2.66	2.66	2.66
MINOR PRINCIPAL STRESS,TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS,TSF		1.90	2.41	3.87
TIME TO MAX DEV,MIN		100	116	122
ULT DEVIATOR STRESS,TSF		1.90	2.41	3.87
INITIAL DIAMETER,IN		1.395	1.402	1.422
INITIAL HEIGHT,IN		2.984	2.980	2.973

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy silt, ML

LL 32 PL 18 PI 4 Gs= 2.71 TYPE SPECIMEN: UNDISTURBED TYPE TEST R

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089
Gray sandy silt, brittle structure, medium consistency, slightly sensitive, low toughness at PL, dull shine, fast shake reaction.

PROJECT: Lake Darling Dam MRD-SA-75-46-RD-F

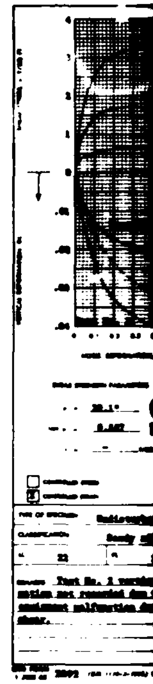
BORING NO: 74-63M SAMPLE NO: 20

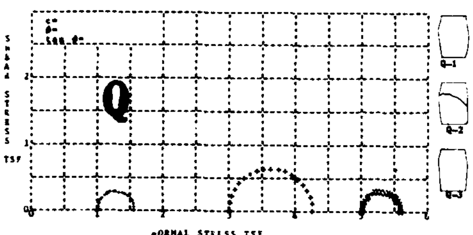
DEPTH: 75.0 - 77.5

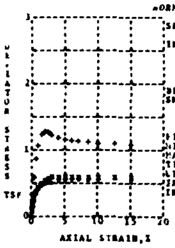
MRD LAB NO: 74/342 75/17 DATE 5 MAY 1975

TRIAXIAL COMPRESSION TEST REPORT
FIGURE 5

②







SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT,%	37.1	38.6	42.[illegible]
	DRY DENSITY,PCF	76.7	79.3	74.1
	SATURATION,%	85	94	9[illegible]
	VOID RATIO	1.10	1.09	1.24
BEFORE SHEAR	WATER CONTENT,%	39.4	33.7	41.6
	DRY DENSITY,PCF	77.3	81.[illegible]	75.2
	SATURATION,%	91	86	9[illegible]
	VOID RATIO	1.15	1.04	1.21
FINAL BACK PRESSURE,TSF		.00	.0[illegible]	.0[illegible]
MINOR PRINCIPAL STRESS,TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS,TSF		.56	1.27	.60
TIME TO MAX DEV,MIN		27	4	5
ULT DEVIATOR STRESS,TSF		.54	1.0[illegible]	.59
INITIAL DIAMETER,IN		1.43[illegible]	1.430	1.39[illegible]
INITIAL HEIGHT,IN		2.963	2.996	3.00[illegible]

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

LL 34 PL 17 PI 17 Gs= 2.66 TYPE SPECIMEN: UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089
Dark gray brittle, soft consistency, slightly sensitive. Low strength at PL, no shine, fast shake reaction.

PROJECT: Lake Darling MRD-SA-76-02

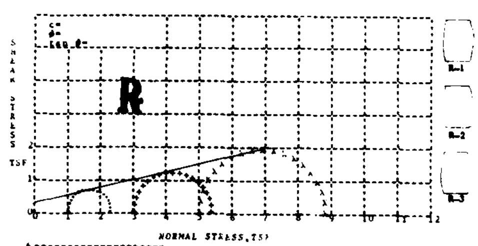
BORING NO: 76-81M SAMPLE NO: 1

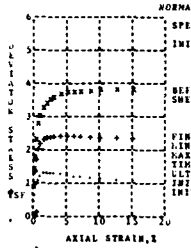
DEPTH: 13.0 - 14.9

MRD LAB NO: 76/116 DATE 15 JUL 1976

TRIAXIAL COMPRESSION TEST REPORT
FIGURE 3

⑤





SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT,%	45.0	49.6	47.4
	DRY DENSITY,PCF	71.7	69.[illegible]	70.[illegible]
	SATURATION,%	91	95	9[illegible]
	VOID RATIO	1.32	1.36	1.[illegible]
BEFORE SHEAR	WATER CONTENT,%	42.6	37.3	29.2
	DRY DENSITY,PCF	76.0	82.9	9[illegible].5
	SATURATION,%	96	99	9[illegible]
	VOID RATIO	1.18	1.00	.8[illegible]
FINAL BACK PRESSURE,TSF		4.70	4.70	4.70
MINOR PRINCIPAL STRESS,TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS,TSF		1.31	2.38	3.00
TIME TO MAX DEV,MIN		15	32	11
ULT DEVIATOR STRESS,TSF		1.07	2.28	3.00
INITIAL DIAMETER,IN		1.421	1.401	1.403
INITIAL HEIGHT,IN		2.996	2.999	2.99[illegible]

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

LL 34 PL 17 PI 17 Gs= 2.66 TYPE SPECIMEN: UNDISTURBED TYPE TEST R

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

B-value = 0.98

PROJECT: Lake Darling MRD-SA-76-02

BORING NO: 76-81M SAMPLE NO: 1

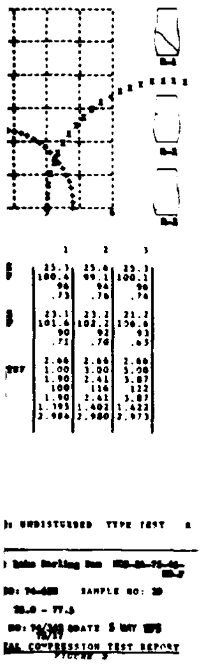
DEPTH: 13.0 - 14.9

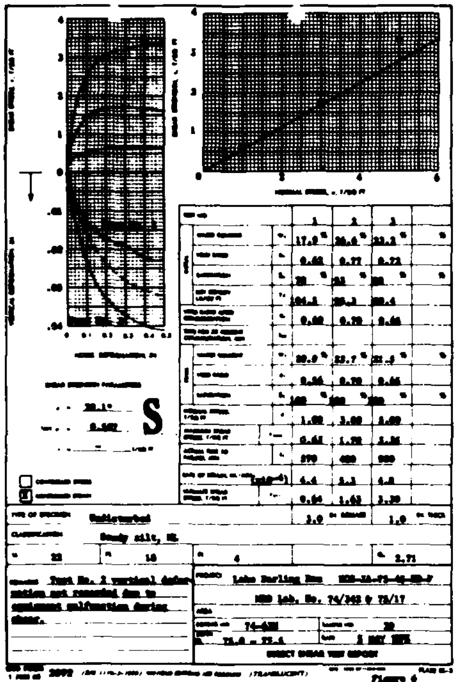
MRD LAB NO: 76/116 DATE 15 JUL 1976

TRIAXIAL COMPRESSION TEST REPORT
FIGURE 2

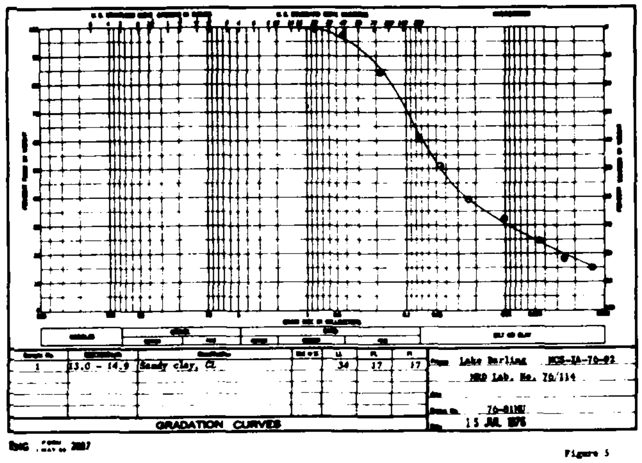
⑥

U. S. ARMY

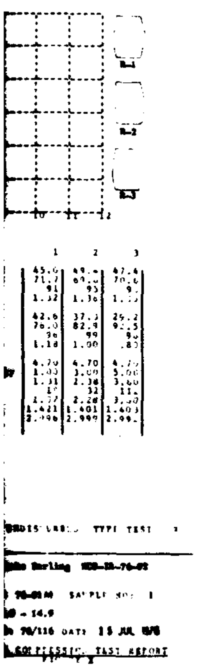


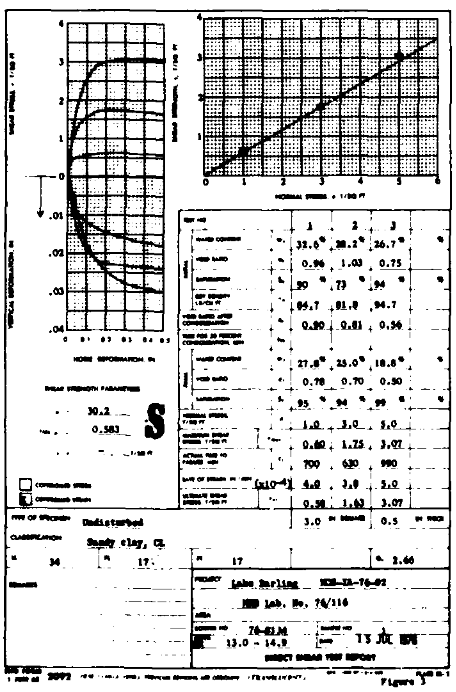


③

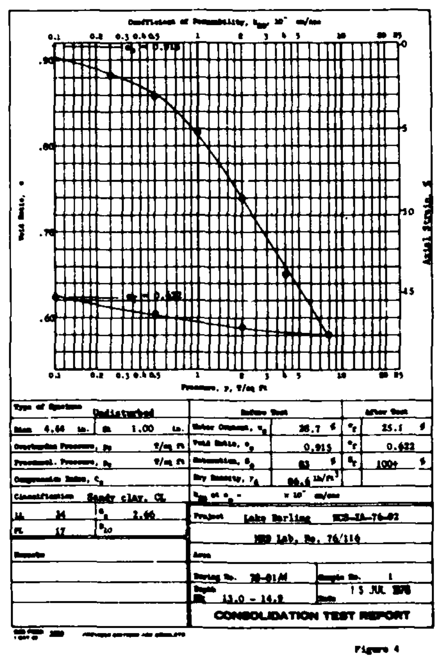


④





⑦



⑧

DESIGN MEMORANDUM NO. 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

SOILS TEST DATA
LAKE DARLING DAM

BORINGS 74-63M AND 76-81M

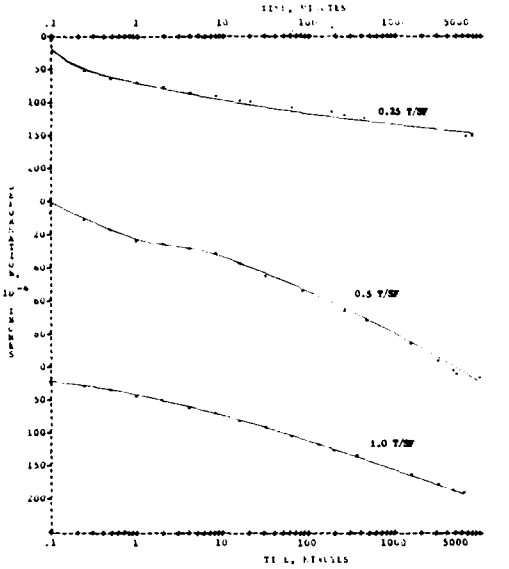
ST PAUL, MINN DISTRICT

JUNE 1983

RI-R-5/782

PLATE NO. B-53

CORPS OF ENGINEERS



PROJECT: Lake Barling MCR-38-76-02

NRD LABORATORY NO: 76/116

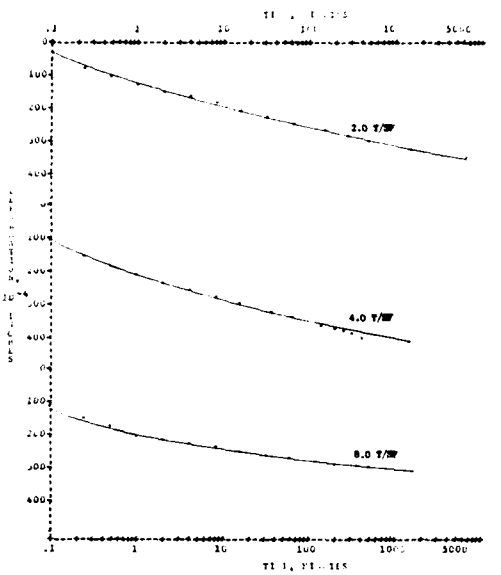
BORING NO: 76-81 SAMPLE NO: 1 DEPTH: 13.0 - 14.9 DATE: 15 JUL 1976

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2087

FIGURE 4a

①



PROJECT: Lake Barling MCR-38-76-02

NRD LABORATORY NO: 76/116

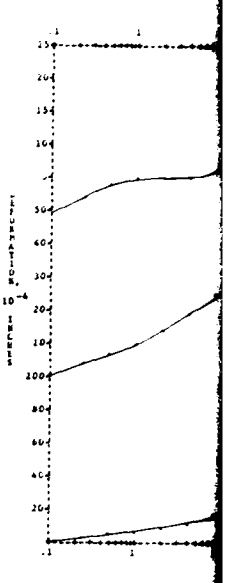
BORING NO: 76-81 SAMPLE NO: 1 DEPTH: 13.0 - 14.9 DATE: 15 JUL 1976

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2087

FIGURE 4b

②



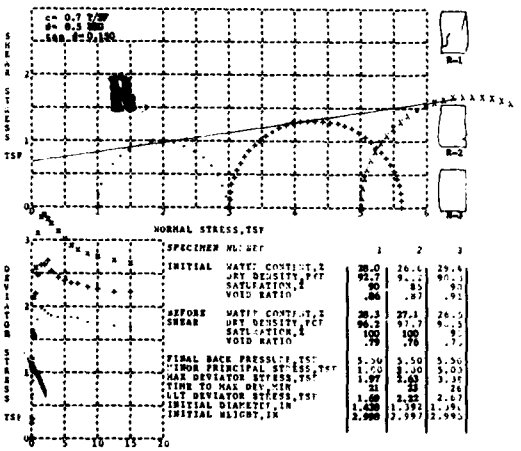
PROJECT: Lake Barling MCR-38-76-02

NRD LABORATORY NO: 76/116

BORING NO: 76-81 SAMPLE NO:

CONSOLIDATION

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2087



SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT, %	28.0	26.6	29.4
	DRY DENSITY, PCF	92.7	94.3	90.3
	SATURATION, %	90	85	93
	VOID RATIO	.84	.87	.91
BEFORE SHEAR	WATER CONTENT, %	28.3	27.1	26.5
	DRY DENSITY, PCF	96.3	97.7	95.5
	SATURATION, %	100	100	95
	VOID RATIO	.79	.76	.79
FINAL BACK PRESSURE, TSF		3.50	3.50	3.50
MINOR PRINCIPAL STRESS, TSF		3.50	3.50	3.50
MAX DEVIATOR STRESS, TSF		1.97	2.03	3.37
TIME TO MAX DEV, MIN		21	22	26
ULT DEVIATOR STRESS, TSF		1.69	2.33	2.67
INITIAL DIAMETER, IN		1.430	1.391	1.491
INITIAL HEIGHT, IN		2.900	2.997	2.993

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

LL 46 PL 26 PI 21 Gs= 2.74 TYPE SPECIMEN: UNDISTURBED TYPE TEST R

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089
Brittle structure, soft consistency, slightly sensitive. Low to medium strength at PL, dull shine, fract shine reaction. Bottom 10" of sample was too small to trim consolidation and Q tests.
B-value = 1.00

PROJECT: Lake Barling MCR-38-76-02

BORING NO: 76-81M SAMPLE NO: 2

DEPTH: 39.0 - 39.9

NRD LAB NO: 76/116 DATE: 15 JUL 1976

TRIAXIAL COMPRESSION TEST REPORT

⑤

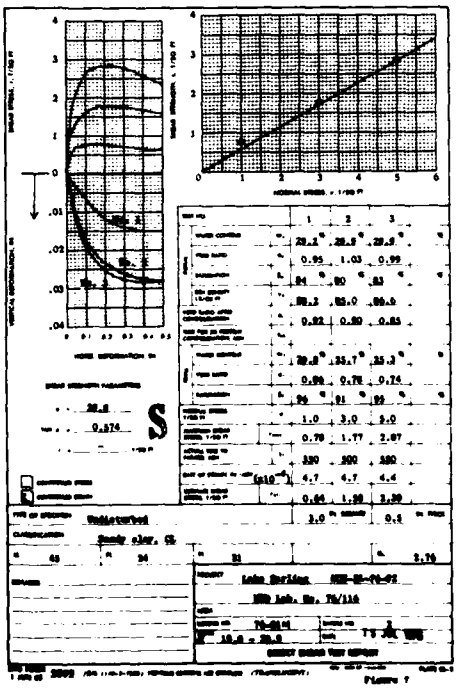
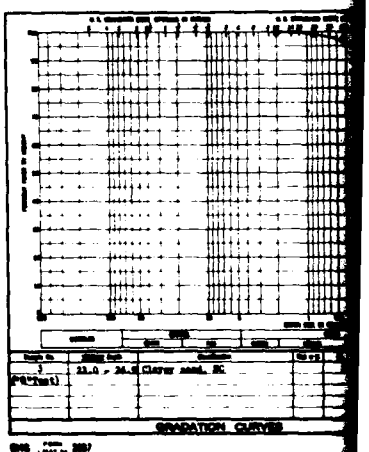
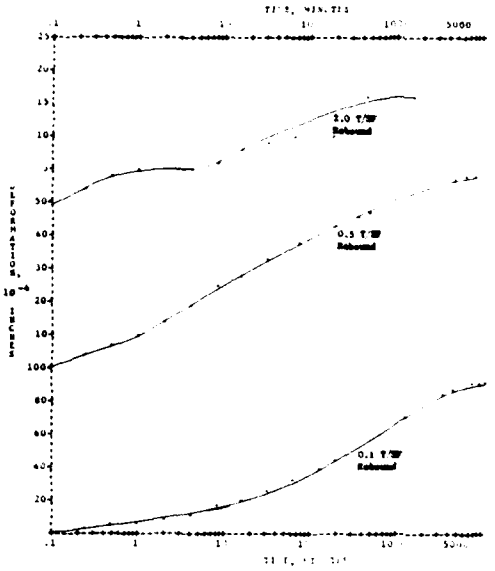


Figure 7

⑥



⑦



PROJECT: Lake Darling MRB-SA-76-02

MRD LABORATORY NO: 76/116

BORING NO: 76-81 SAMPLE NO: 1 DEPTH: 13.0 - 14.9 DATE: 15 JUL 1976

CONSOLE A-304 TEST -- TEST CURVES

ACHIEL PRINT OUT
FORMAT AFTER ENG FORM 20 0

FIGURE 4c

③

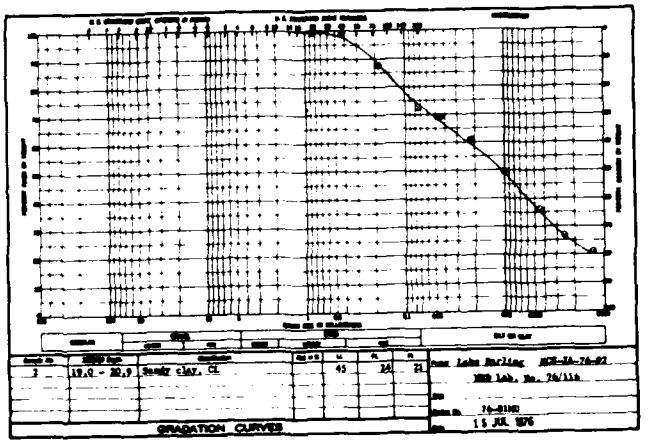


Figure 8

④

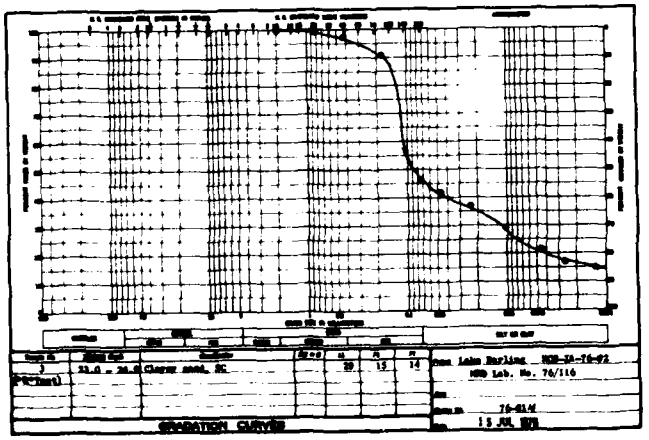


Figure 10

⑦

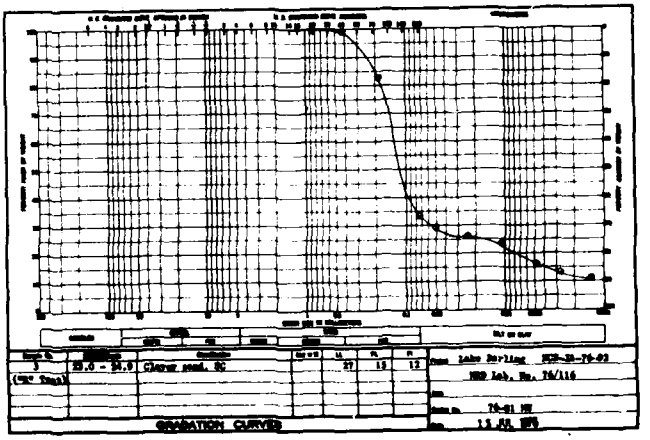


Figure 12

⑧

DESIGN MEMORANDUM NO. 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

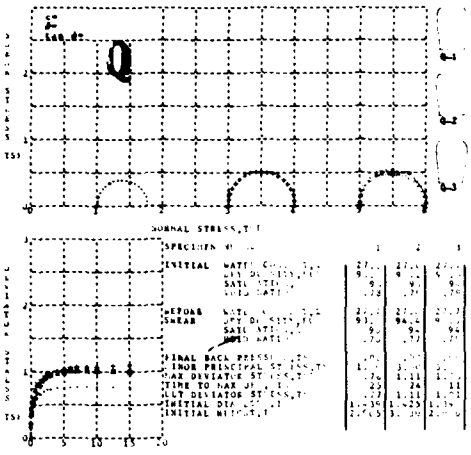
SOILS TEST DATA
LAKE DARLING DAM

BORING 76-81 MU

ST PAUL, MINN DISTRICT

JUNE 1983

PLATE NO. B-54



CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Clayey sand, SC

LL 29 PL 15 PI 14 Gs= 2.66 TYPE SPECIMEN: UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT FORMAT AFTER LNG FORM 2049

Light gray clayey sand with clay seams of brittle structure, soft consistency, and slightly sensitive. Low to medium strength at PL, no shine and a fast shake reaction.

PROJECT: Lake Barling MCS-1A-76-92

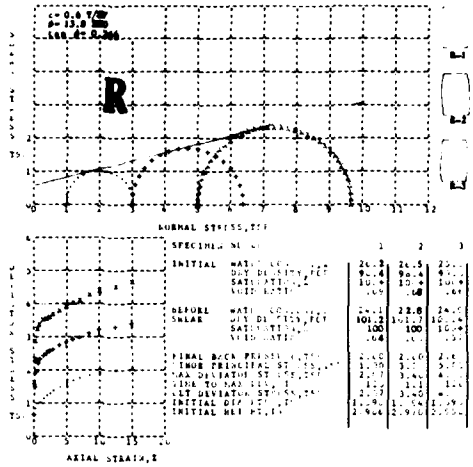
BORING NO: 76-81M SAMPLE NO: 3

DEPTH: 33.0 - 34.9

MRD LAB NO: 76/116 DATE 15 JUL 1976

TRIAXIAL COMPRESSION TEST REPORT

①



CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Clayey sand, SC

LL 27 PL 15 PI 12 Gs= 2.66 TYPE SPECIMEN: UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT FORMAT AFTER LNG FORM 2049

Light gray clayey sand of brittle structure, soft consistency, and slightly sensitive. Medium strength at PL, no shine and a fast shake reaction. B-value = 0.97

PROJECT: Lake Barling MCS-1A-76-92

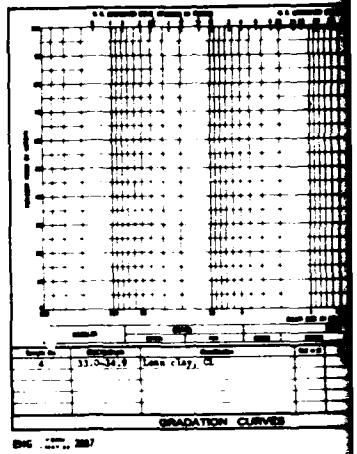
BORING NO: 76-81M SAMPLE NO: 3

DEPTH: 33.0 - 34.9

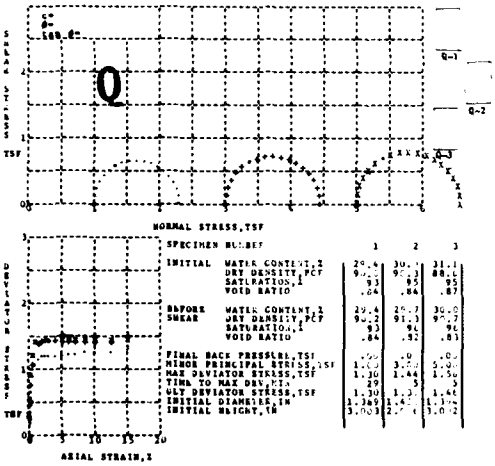
MRD LAB NO: 76/116 DATE 15 JUL 1976

TRIAXIAL COMPRESSION TEST REPORT

②



③



CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Fat clay, CH

LL 50 PL 22 PI 28 Gs= 2.66 TYPE SPECIMEN: UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT FORMAT AFTER LNG FORM 2049

PROJECT: Lake Barling Dam MCS-1A-76-92-ED-1

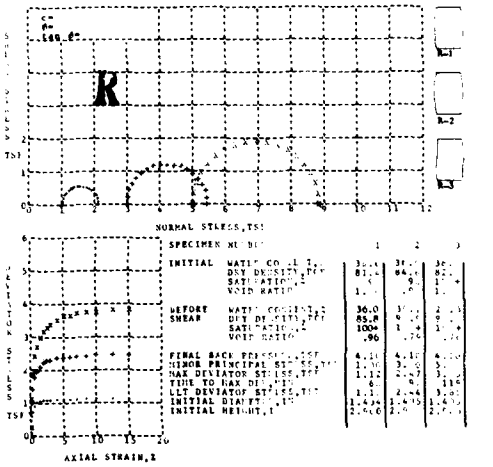
BORING NO: 76-81M SAMPLE NO: 4

DEPTH: 33.0 - 34.9

MRD LAB NO: 76/116 DATE 5 AUG 1976

TRIAXIAL COMPRESSION TEST REPORT

⑤



CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Lean clay, CL

LL 44 PL 21 PI 23 Gs 2.69 TYPE SPECIMEN: UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT FORMAT AFTER LNG FORM 2049

Gray, brittle structure, medium consistency, insensitive. Low strength at PL, dull shine, slow shake reaction. B-value = 0.95

PROJECT: Lake Barling Dam MCS-1A-76-92-ED-2

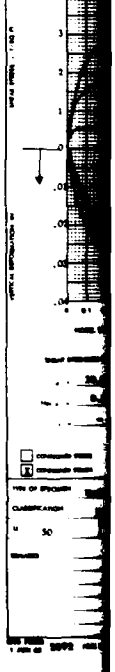
BORING NO: 76-81M SAMPLE NO: 4

DEPTH: 33.0 - 34.9

MRD LAB NO: 76/116 DATE 5 AUG 1976

TRIAXIAL COMPRESSION TEST REPORT

⑥



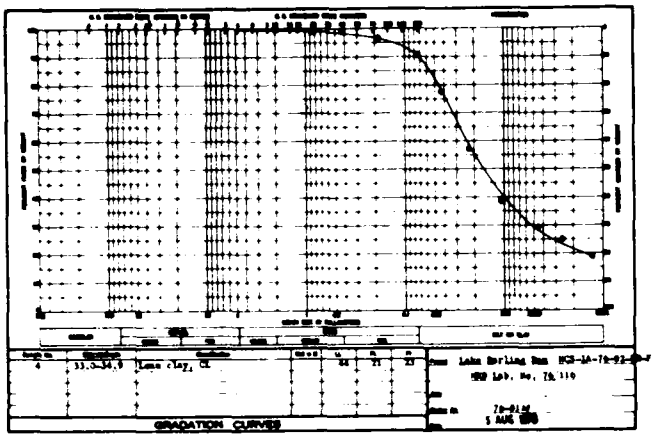


Figure 5

③

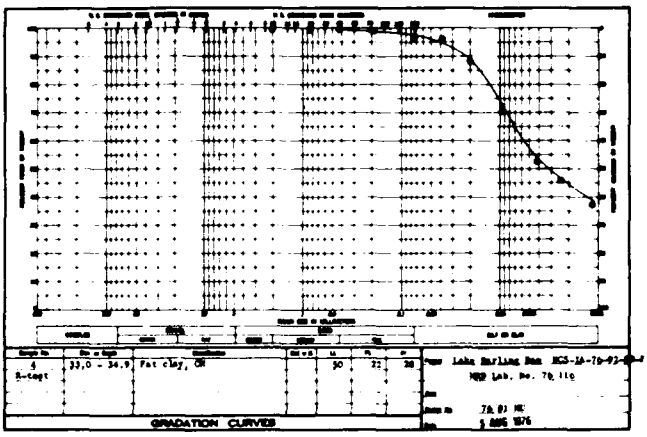


Figure 6

④

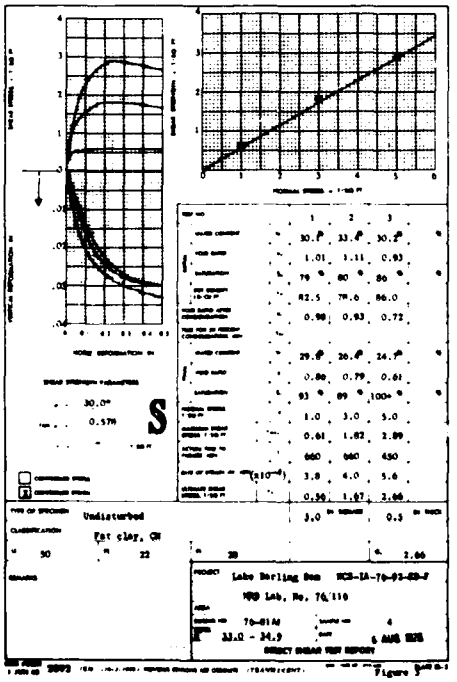


Figure 7

⑦

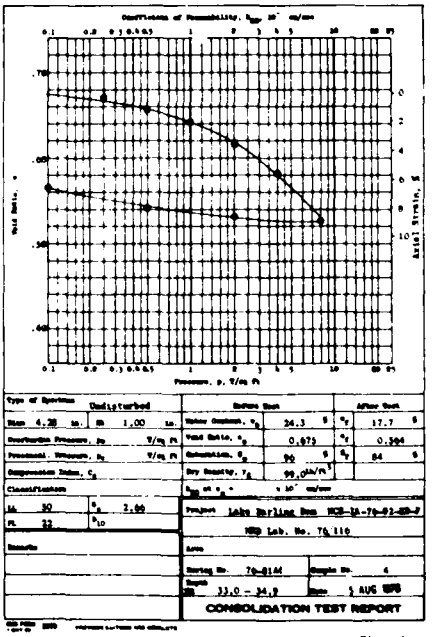


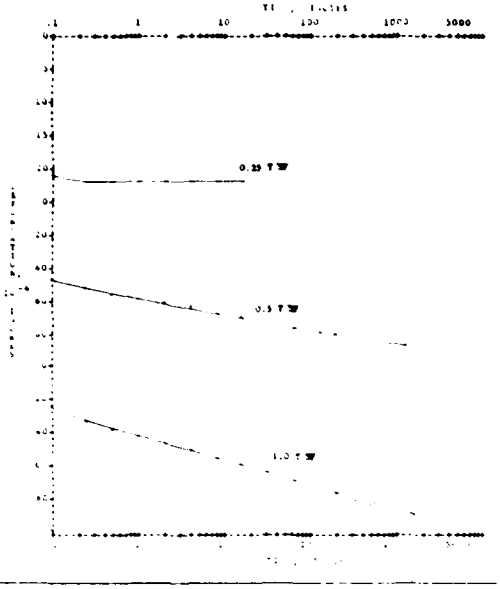
Figure 4

⑧

DESIGN MEMORANDUM NO. 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
SOILS TEST DATA
LAKE DARLING DAM
BORING 76-81 M
ST. PAUL, MINN DISTRICT
JUNE 1983

RI-R-8/784

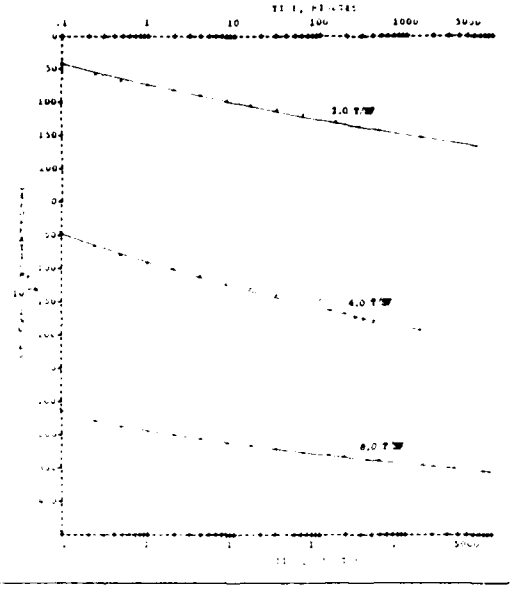
PLATE NO. B-55



PROJECT: Lake Darling Dam NCS-IA-76-92-ED-F

5 AUG 1976

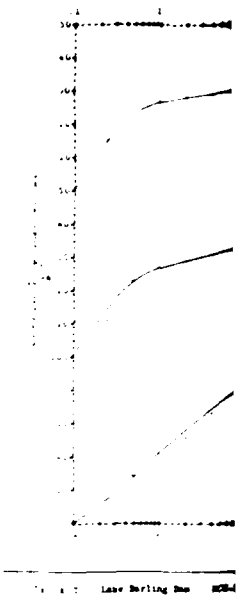
①



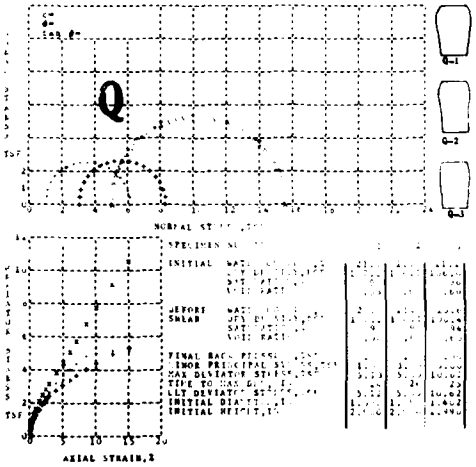
PROJECT: Lake Darling Dam NCS-IA-76-92-ED-F

5 AUG 1976

②



Lake Darling Dam



CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

LL 43 PL 17 PI 26 Gs= 2.72 TYPE SPECIMEN: U IN LIEU TYPE TEST: Q

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2089

Dark gray, of brittle structure, medium consistency, and slightly sensitive. High strength at Pl, slight gloss shine, and no shake reaction.

6 Specimens were very sandy.

PROJECT: Lake Darling NCS-IA-76-92

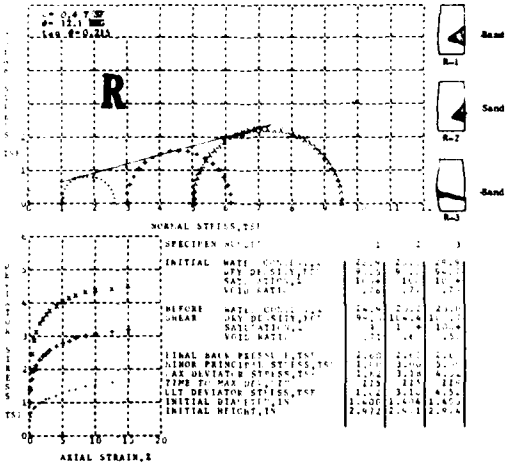
BORING NO: 76-81M SAMPLE NO: S

DEPTH: 43.4 - 45.2

MFG LAB NO: 76/116 DATE 15 JUL 1976

TRIAXIAL COMPRESSION TEST REPORT

⑤



CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

LL 43 PL 17 PI 26 Gs= 2.72 TYPE SPECIMEN: U IN LIEU TYPE TEST: R

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2089

R-value = 0.98

PROJECT: Lake Darling NCS-IA-76-92

BORING NO: 76-81M SAMPLE NO: S

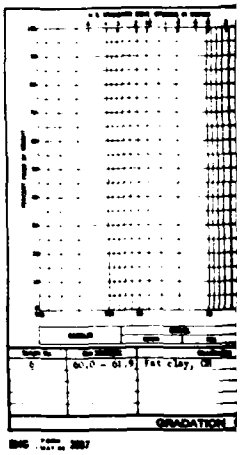
DEPTH: 43.4 - 45.2

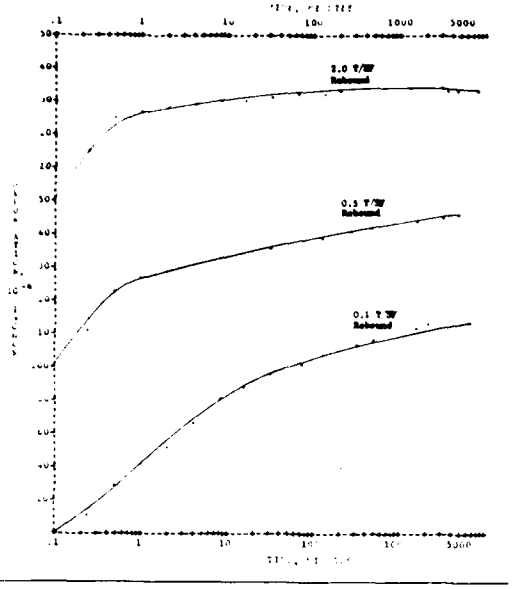
MFG LAB NO: 76/116 DATE 15 JUL 1976

TRIAXIAL COMPRESSION TEST REPORT

⑥

SEE





PROJECT: Lake Darling Dam MCS-IA-76-82-ED-F

MRD LABORATORY NO: 76-110

BORING NO: 76-81 SAMPLE NO: 4 DEPTH: 33.0 - 34.9 DATE: 5 AUG 1976

CONSOLIDATION TEST REPORT

MACHINE PRINT OUT FORMAT AFTER ENG FORM 2087

FIGURE 7

③

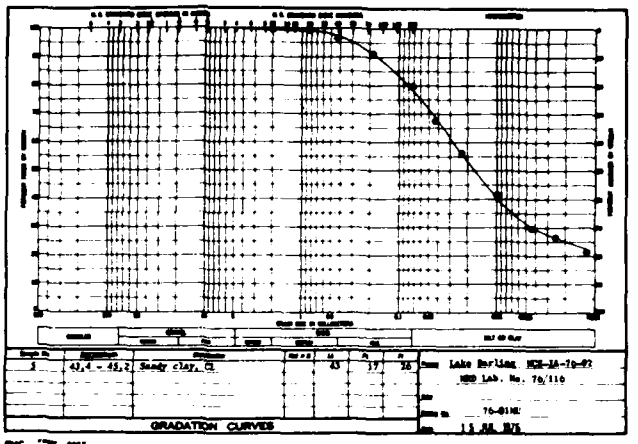


Figure 15

④

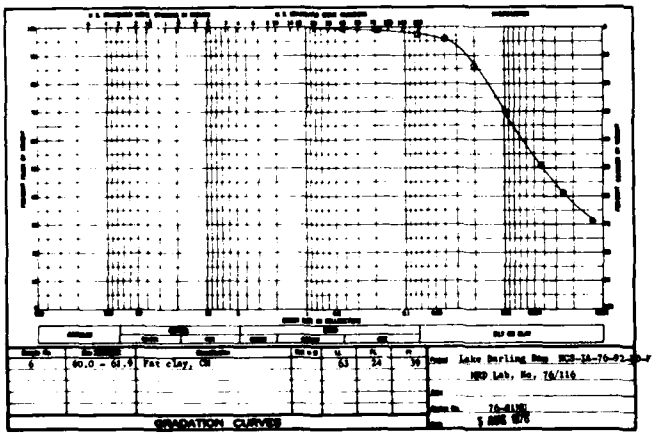
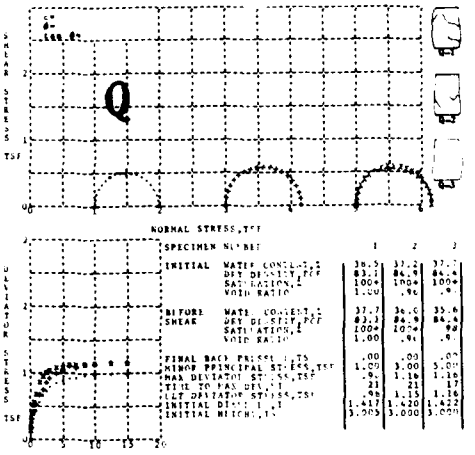


Figure 16

⑦



SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT, %	36.5	37.2	37.1
	DRY DENSITY, PCF	83.1	84.5	84.4
	SATURATION, %	100+	100+	100+
	VOID RATIO	1.00	.96	.96
BEFORE SHEAR	WATER CONTENT, %	37.7	36.6	35.6
	DRY DENSITY, PCF	83.1	84.9	84.6
	SATURATION, %	100+	100+	99
	VOID RATIO	1.00	.96	.95
FINAL BACK PRESSURE, TSF		.00	.00	.00
MINOR PRINCIPAL STRESS, TSF		1.00	3.00	5.00
MAX DEVIATION STRESS, TSF		.96	1.19	1.18
TIME TO FAILURE, HR		.21	.21	.17
ULT DEVIATOR STRESS, TSF		.96	1.19	1.18
INITIAL DIAMETER, IN		1.417	1.420	1.422
INITIAL HEIGHT, IN		3.005	3.000	3.000

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Fat clay, CH

LL 63 PL 24 PI 39 Gs= 2.64 TYPE SPECIMENS UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2089

Gray, brittle structure, medium consistency, sensitive. Medium strength at PL, gloss to high gloss shine, no shake reaction.

PROJECT: Lake Darling Dam MCS-IA-76-82-ED-F

BORING NO: 76-81M SAMPLE NO: 6

DEPTH: 60.0 - 61.9

MRD LAB NO: 76/116 DATE: 5 AUG 76

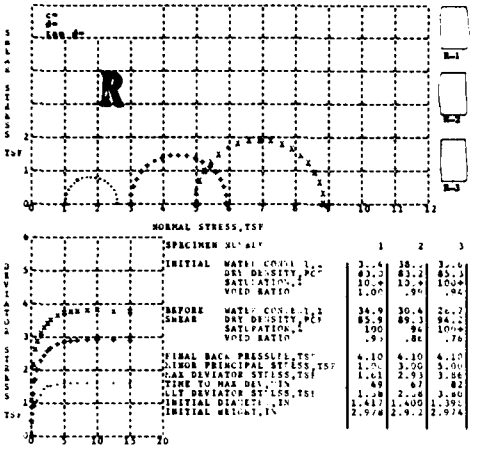
TRIAXIAL COMPRESSION TEST REPORT
FIGURE 10

⑧

DESIGN MEMORANDUM NO. 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
SOILS TEST DATA
LAKE DARLING DAM
BORING 76-81 M
ST PAUL, MINN DISTRICT
JUNE 1983

RI-R-8/788

PLATE NO. B-56



		1	2	3
SPECIMEN NUMBER				
INITIAL	WATER CONTENT, %	34.4	38.[illegible]	34.6
	DRY DENSITY, PCF	83.3	83.2	83.3
	SATURATION, %	100.0	100.0	100.0
	VOID RATIO	1.00	.99	.98
BEFORE SHEAR	WATER CONTENT, %	34.9	30.4	26.2
	DRY DENSITY, PCF	85.9	89.3	94.1
	SATURATION, %	100	96	100
	VOID RATIO	.93	.86	.76
FINAL BACK PRESSURE, TSF		4.10	4.10	4.10
MINOR PRINCIPAL STRESS, TSF		1.70	3.00	5.00
MAX DEVIATOR STRESS, TSF		1.61	2.93	3.86
TIME TO MAX DEV., MIN		49	67	82
ULT DEVIATOR STRESS, TSF		1.28	2.26	3.60
INITIAL DIAMETER, IN		1.417	1.400	1.391
INITIAL HEIGHT, IN		2.978	2.978	2.974

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Fat clay, CH

LL 63 PL 24 PI 39 Gs= ASSUMED TYPE SPECIMEN: ADJUSTABLE TYPE TEST: R

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ERC FORM 2089

B-value = 0.99

PROJECT: Lake Barling MCS-1A-76-02-ED-F

BORING NO: 76-01M SAMPLE NO: 6

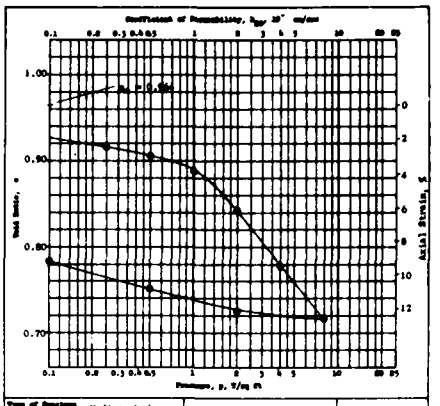
DEPTH: 60.0 - 61.9

MED LAB NO: 76'116 DATE: 8 AUG 1976

TRIAXIAL COMPRESSION TEST REPORT

FIGURE 11

①

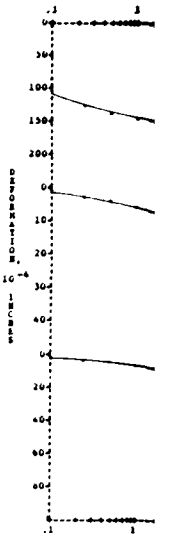


Type of Specimen: Undisturbed			Before Test		After Test	
Diam. 4.44 in.	Ht. 1.00 in.		Water Content, w_o	35.0 %	w_f	31.1 %
Consolidation Pressure, p_o	T/sq ft		Void Ratio, e_o	0.964	e_f	0.783
Permeant. Pressure, p_p	T/sq ft		Saturation, S_o	98 %	S_f	100 %
Compression Index, C_c			Dry Density, γ_d	84.5 lb/ft³		
Classification: Fat clay, CH			k_{20} at e_o =	x 10⁻⁸ cm/sec		
LL 63	e_o 2.66		Project: Lake Barling Dam MCS-1A-76-02-ED-F			
PL 24	A_{10}		MED Lab. No. 76'116			
Remarks:			Area			
			Boring No. 76-01M	Sample No. 6		
			Depth: 60.0 - 61.9	Date: 5 AUG 1976		

CONSOLIDATION TEST REPORT

Figure 12

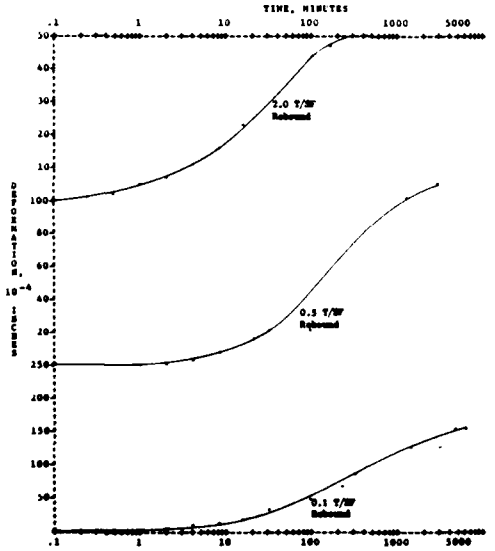
②



PROJECT: Lake Barling Da
MED LABORATORY NO: 76
BORING NO: 76-01 SAM

MACHINE PRINT OUT
FORMAT AFTER ERC FORM

* SEE



PROJECT: Lake Barling Dam MCS-1A-76-02-ED-F

MED LABORATORY NO: 76/116

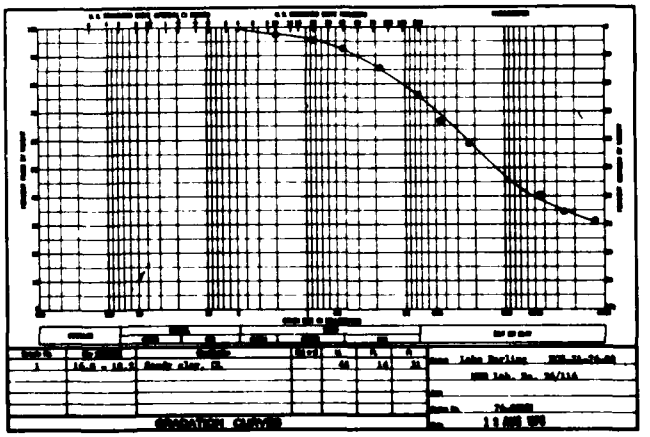
BORING NO: 76-01 SAMPLE NO: 6 DEPTH: 60.0 - 61.9 DATE: 5 AUG 1976

CONSOLIDATION TEST -- TIME CURVE

MACHINE PRINT OUT
FORMAT AFTER ERC Form 2066

FIGURE 13

⑤

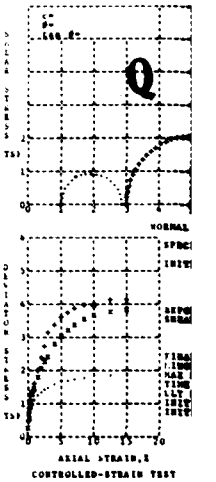


Sample No.	Depth	Classification	LL	PL	PI
1	16.8 - 18.9	Sandy clay, CL	46	14	32

Project: Lake Barling MCS-1A-76-02-ED-F
MED Lab. No. 76/116
Boring No. 76-01MED
Date: 11 AUG 1976

Figure 14

⑥



CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS:

LL 46 PL 14 PI 32 Gs=

REMARKS: MACHINE PRINT O
FORMAT AFTER ERC FORM 20
Gray, brittle, medium consist
slightly sensitive. High sh
at PL, gloss chips, no shine

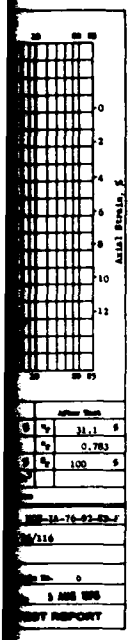
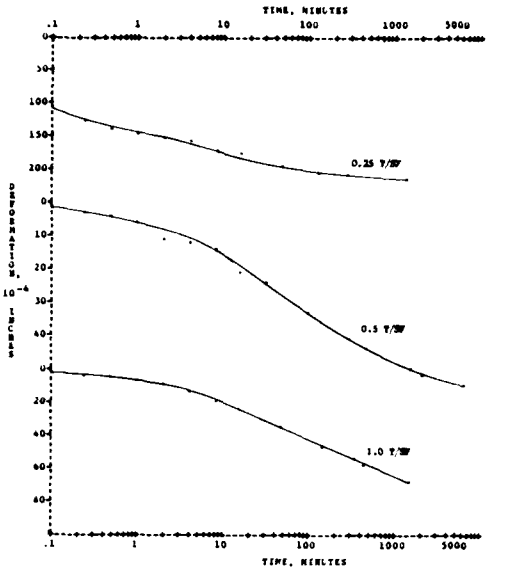


Figure 12



PROJECT: Lake Darling Dam NCS-IA-76-92-ED-F

MRD LABORATORY NO: 76/116

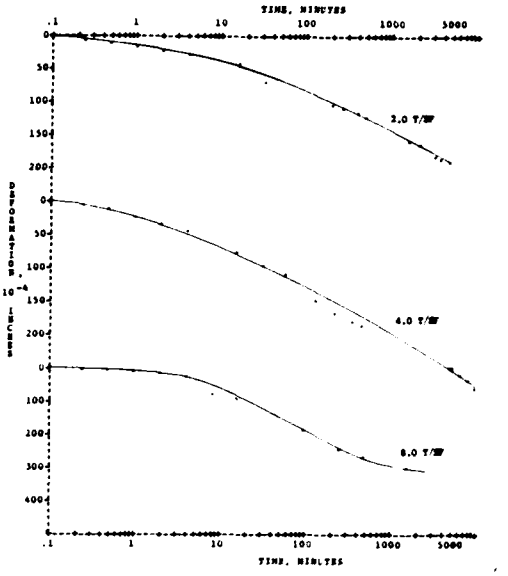
BORING NO: 76-81 SAMPLE NO: 8 DEPTH: 60.0 - 61.9 DATE: 8 AUG 1976

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

FIG RE 13

③



PROJECT: Lake Darling Dam NCS-IA-76-92-ED-F

MRD LABORATORY NO: 76/116

BORING NO: 76-81 SAMPLE NO: 8 DEPTH: 60.0 - 61.9 DATE: 8 AUG 1976

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

FIG RE 14

④

* SEE NOTE PLATE B-49

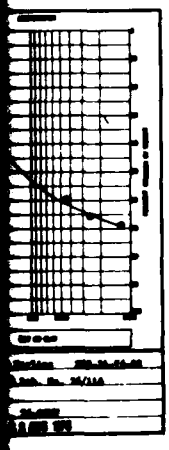
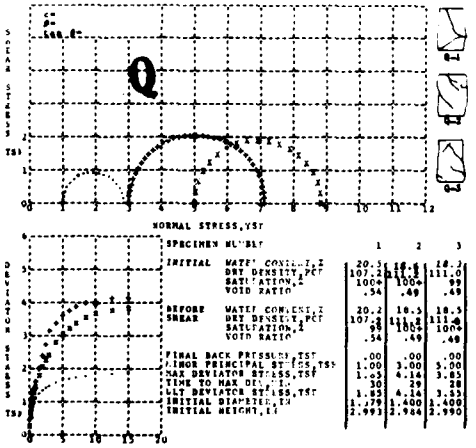


Figure 15



SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT,%	20.3	18.5	18.3
	DRY DENSITY,PCF	107.2	111.2	111.0
	SATURATION,%	100+	100+	99
	VOID RATIO	.54	.49	.49
BEFORE SHEAR	WATER CONTENT,%	20.2	18.5	18.5
	DRY DENSITY,PCF	107.2	111.2	111.0
	SATURATION,%	98	100+	100+
	VOID RATIO	.54	.49	.49
FINAL BACK PRESSURE,TSF		.00	.00	.00
MINOR PRINCIPAL STRESS,TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS,TSF		1.63	4.14	3.85
TIME TO MAX DEV.,MIN.		30	29	28
ULT DEVIATOR STRESS,TSF		1.85	4.14	3.55
INITIAL DIAMETER,IN		1.778	1.400	1.400
INITIAL HEIGHT,IN		2.993	2.984	2.990

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

LL 46 PL 16 PI 30 Gs= 2.62 TYPE OF TEST: UNCONSOLIDATED UNDRAINED TYPE TEST Q

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

Gray, brittle, medium consistency, slightly sensitive. High strength at PL, gloss shine, no shake reaction.

PROJECT: Lake Darling NCS-IA-76-92

BORING NO: 76-90M SAMPLE NO: 1

DEPTH: 16.0 - 18.2

MRD LAB NO: 76/116 DATE 11 AUG 1976

TRIAXIAL COMPRESSION TEST REPORT
FIGURE 16

⑦

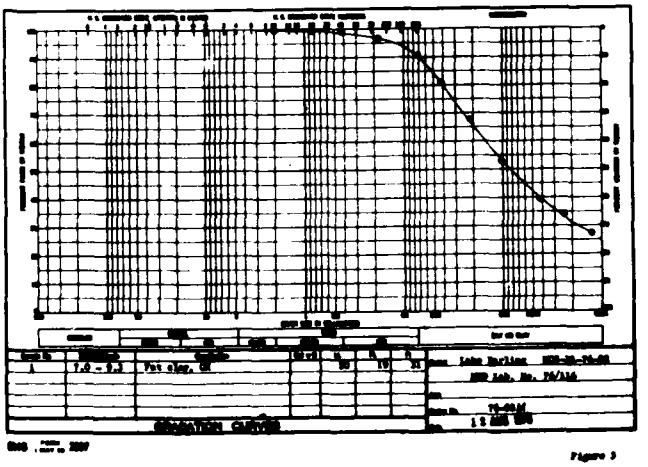


Figure 3

⑤

DESIGN MEMORANDUM NO. 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

SOILS TEST DATA

LAKE DARLING DAM

BORINGS 76-81M, 76-90M AND 76-93M

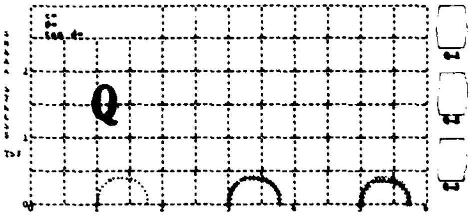
ST. PAUL, MINN. DISTRICT

AUG 1976

RI-R-6/766

PLATE NO. B-57

CORPS OF ENGINEERS



SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT,%	26.5	27.2	28.5
	DRY DENSITY,PCF	95.3	97.5	96.1
	SATURATION,%	94	100+	100
	VOID RATIO	.77	.73	.76
BEFORE SHEAR	WATER CONTENT,%	26.9	26.9	27.9
	DRY DENSITY,PCF	95.3	97.5	96.1
	SATURATION,%	9.	9.	99
	VOID RATIO	.77	.73	.76
FINAL BACK PRESSURE,TSF		.00	.00	.00
MINOR PRINCIPAL STRESS,TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS,TSF		.79	.79	.73
TIME TO MAX DEV,MIN		24	24	24
ULT DEVIATOR STRESS,TSF		.79	.79	.73
INITIAL DIAMETER,IN		1.416	1.429	1.410
INITIAL HEIGHT,IN		3.000	2.996	2.995

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Fat clay, CH

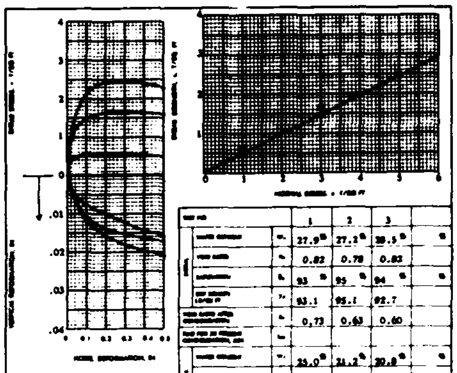
LL 50 PL 19 PI 31 Gs= 2.71 TYPE SPECIMEN: UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

Mottled grey, brittle structure, medium consistency, slightly sensitive. High strength at PL, gloss shine, no shake reaction.

PROJECT: Lake Darling MCS-IA-76-02
BORING NO: 76-03M SAMPLE NO: 1
DEPTH: 7.0 - 9.3
MRD LAB NO: 76/92 DATE 12 AUG 1976
TRIAXIAL COMPRESSION TEST REPORT
FIGURE 1

①



SHEAR STRENGTH PARAMETERS
φ = 26.0°
tan φ = 0.488

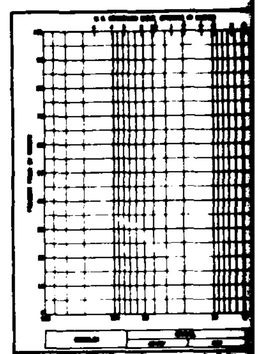
TEST NO.		1	2	3	
[illegible]	w_o	27.9%	27.2%	28.5%	%
[illegible]	e_o	0.82	0.78	0.82	
[illegible]	S_o	93 %	95 %	94 %	%
[illegible]	γ_d	93.1	95.1	92.7	
[illegible]	e_c	0.73	0.63	0.60	
[illegible]	t_{50}				
[illegible]	w_f	25.0%	21.2%	20.8%	%
[illegible]	e_f	0.67	0.58	0.53	
[illegible]	S_f	100 %	100 %	100+ %	%
[illegible]	σ	1.0	3.0	5.0	
[illegible]	τ_{max}	0.58	1.66	2.44	
[illegible]	t_f	500	600	500	
[illegible] (x10⁻⁴)		4.2	4.0	6.0	
[illegible]	τ_{ult}	0.50	1.61	2.28	
		3.0 IN. SQUARE		0.5 IN. THICK	

TYPE OF SPECIMEN: Undisturbed
CLASSIFICATION: Fat clay, CH
LL 50 PL 19 PI 31 Gs 2.71

PROJECT: Lake Darling MCS-IA-76-02
MRD Lab. No. 76/116
BORING NO. 76-03M SAMPLE NO. 1
DEPTH 7.0 - 9.3 DATE 12 AUG 1976
DIRECT SHEAR TEST REPORT

ENG FORM 1 APR 60 2092 (TRANSLUCENT) Figure 2

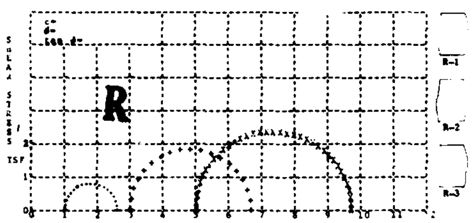
②

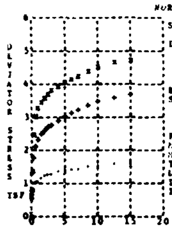


Sample No.	Elev or Depth	Classification
2	12.0 - 14.4	Sandy clay, CL

GRADATION

ENG FORM MAY 63 2087





SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT,%	29.0	27.1	26.7
	DRY DENSITY,PCF	9..0	101.5	101.0
	SATURATION,%	100+	100+	100+
	VOID RATIO	.69	.6.	.64
BEFORE SHEAR	WATER CONTENT,%	24.3	19.5	19.2
	DRY DENSITY,PCF	99.4	105.3	106.2
	SATURATION,%	96	96	96
	VOID RATIO	.67	.5.	.5.
FINAL BACK PRESSURE,TSF		2.66	2.66	2.66
MINOR PRINCIPAL STRESS,TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS,TSF		1.61	3.6.	4.74
TIME TO MAX DEV,MIN		114	117	121
ULT DEVIATOR STRESS,TSF		1.61	3.68	4.74
INITIAL DIAMETER,IN		1.405	1.396	1.404
INITIAL HEIGHT,IN		2.946	2.942	2.945

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

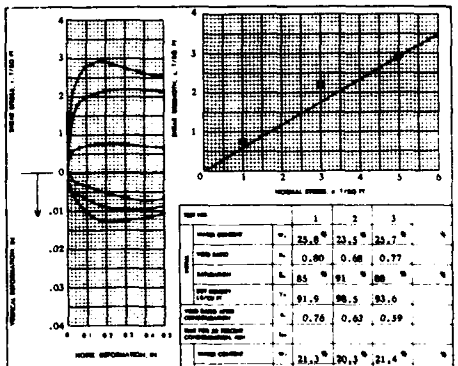
LL 26 PL 14 PI 12 Gs= 2.66 TYPE SPECIMEN: UNDISTURBED TYPE TEST R

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

B-value = 1.00

PROJECT: Lake Darling MCS-IA-76-02
BORING NO: 76-03M SAMPLE NO: 2
DEPTH: 12.0 - 14.4
MRD LAB NO: 76/116 DATE 11 AUG 1976
TRIAXIAL COMPRESSION TEST REPORT
FIGURE 5

⑤



SHEAR STRENGTH PARAMETERS
φ = 30.3°
tan φ = 0.584

TEST NO.		1	2	3	
[illegible]	w_o	25.8%	23.5%	25.7%	%
[illegible]	e_o	0.80	0.68	0.77	
[illegible]	S_o	85 %	91 %	88 %	%
[illegible]	γ_d	91.9	98.5	93.6	
[illegible]	e_c	0.76	0.63	0.59	
[illegible]	t_{50}				
[illegible]	w_f	21.3%	20.3%	21.4%	%
[illegible]	e_f	0.72	0.61	0.54	
[illegible]	S_f	78 %	88 %	100 %	%
[illegible]	σ	1.0	3.0	5.0	
[illegible]	τ_{max}	0.74	2.20	2.92	
[illegible]	t_f	700	700	700	
[illegible] (x10⁻⁴)		4.5	4.3	4.0	
[illegible]	τ_{ult}	0.67	2.13	2.54	
		3.0 IN. SQUARE		0.5 IN. THICK	

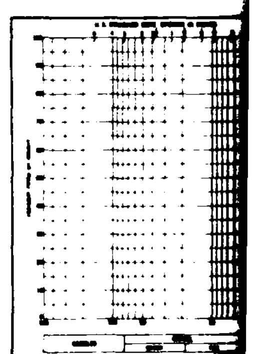
TYPE OF SPECIMEN: Undisturbed
CLASSIFICATION: Sandy clay, CL
LL 26 PL 14 PI 12 Gs 2.66

PROJECT: Lake Darling MCS-IA-76-02
MRD Lab. No. 76/116
BORING NO. 76-03M SAMPLE NO. 2
DEPTH 12.0 - 14.4 DATE 11 AUG 1976
DIRECT SHEAR TEST REPORT

ENG FORM 1 APR 60 2092 (TRANSLUCENT) Figure 6

⑥

* SEE NO



Sample No.	Elev or Depth	Classification
3	17.0 - 19.0	Clayey sand

GRADATION

ENG FORM MAY 63 2087

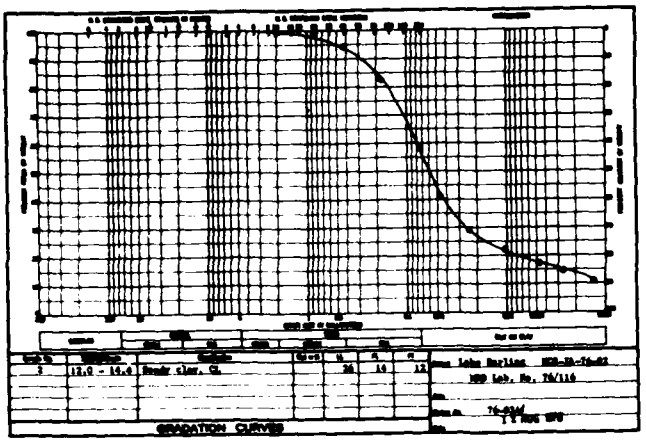
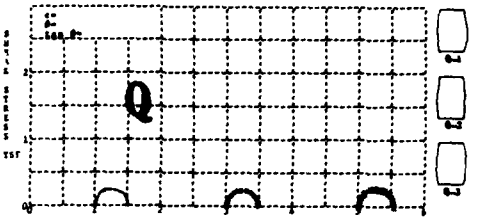


Figure 7

③



	SPECIMEN NUMBER	1	2	3
INITIAL	WATER CONTENT,%	21.2	22.0	22.6
	DRY DENSITY,PCF	98.1	96.3	96.3
	SATURATION,%	96	99	100
	VOID RATIO	.76	.81	.73
BEFORE SHEAR	WATER CONTENT,%	22.4	19.3	22.4
	DRY DENSITY,PCF	98.1	96.3	96.3
	SATURATION,%	100	97	95
	VOID RATIO	.76	.81	.73
FINAL BACK PRESSURE,TSF		.00	.00	.00
MINOR PRINCIPAL STRESS,TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS,TSF		.50	.49	.54
TIME TO MAX. DEV.,hr		.24	.24	.24
ULT DEVIATOR STRESS,TSF		.50	.49	.54
INITIAL DIAMETER,in		1.407	1.412	1.406
INITIAL HEIGHT,in		3.050	2.980	2.9.0

AXIAL STRAIN,%

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

LL 26 PL 14 PI 12 Gs= 2.66 TYPE SPECIMENS UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2089

Brown, brittle structure, soft consistency, medium strength at PL, dull shine, slow shake reaction.

PROJECT: Lake Darling MDR-SA-76-93

BORING NO: 76-93M SAMPLE NO: 2

DEPTH: 12.0 - 14.4

MRD LAB NO: 76/116 DATE 12 AUG 1976

TRIAXIAL COMPRESSION TEST REPORT

④

* SEE NOTE PLATE B-48

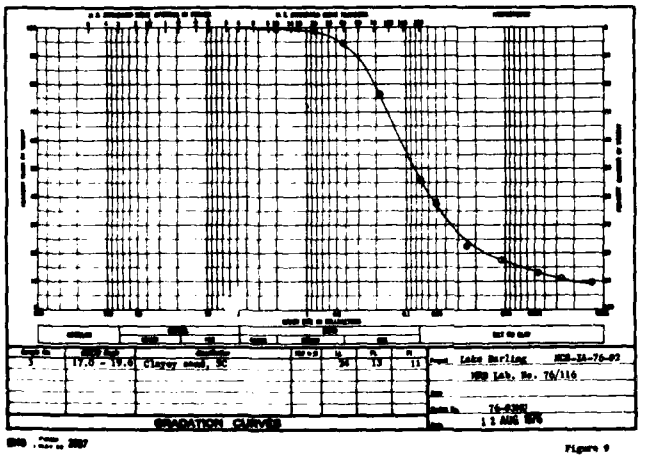
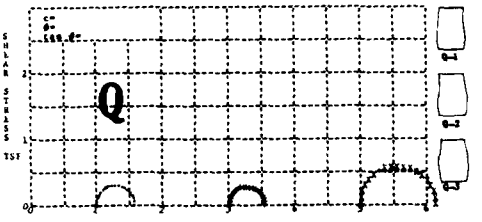


Figure 9

⑦



	SPECIMEN NUMBER	1	2	3
INITIAL	WATER CONTENT,%	21.-	21.6	20.1
	DRY DENSITY,PCF	102.6	104.1	106.2
	SATURATION,%	96	99	97
	VOID RATIO	.60	.58	.55
BEFORE SHEAR	WATER CONTENT,%	21.3	21.6	19.-
	DRY DENSITY,PCF	102.6	104.1	106.2
	SATURATION,%	94	99	93
	VOID RATIO	.60	.58	.55
FINAL BACK PRESSURE,TSF		.00	.00	.00
MINOR PRINCIPAL STRESS,TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS,TSF		.59	.54	1.15
TIME TO MAX. DEV.,hr		.24	.24	.23
ULT DEVIATOR STRESS,TSF		.59	.54	1.15
INITIAL DIAMETER,in		1.391	1.384	1.405
INITIAL HEIGHT,in		2.999	2.995	2.9.0

AXIAL STRAIN,%

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Clayey sand, SC

LL 20 PL 13 PI 11 Gs= 2.63 TYPE SPECIMENS UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2089

Light brown, brittle structure, insensitive. Low strength at PL, dull shine, fast shake reaction.

PROJECT: Lake Darling MDR-SA-76-93

BORING NO: 76-93M SAMPLE NO: 3

DEPTH: 17.0 - 19.6

MRD LAB NO: 76/116DATE 12 AUG 1976

TRIAXIAL COMPRESSION TEST REPORT

⑧

DESIGN MEMORANDUM NO. 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

SOILS TEST DATA
LAKE DARLING DAM

BORING 76-93M

ST PAUL, MINN DISTRICT

JUNE 1981

RI-R-S/757

PLATE NO. B-59

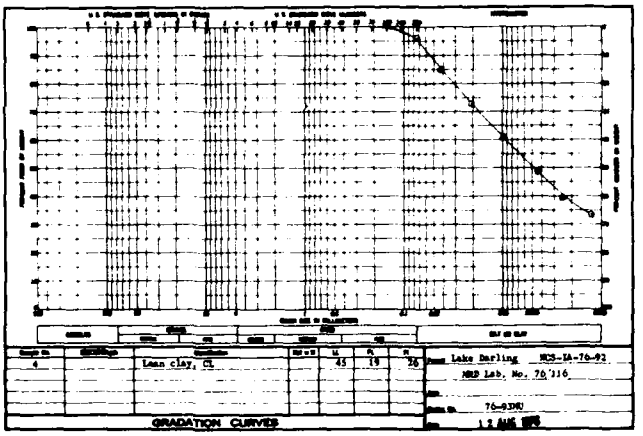


Figure 11

①

* SEE NOTE PLATE 8-49

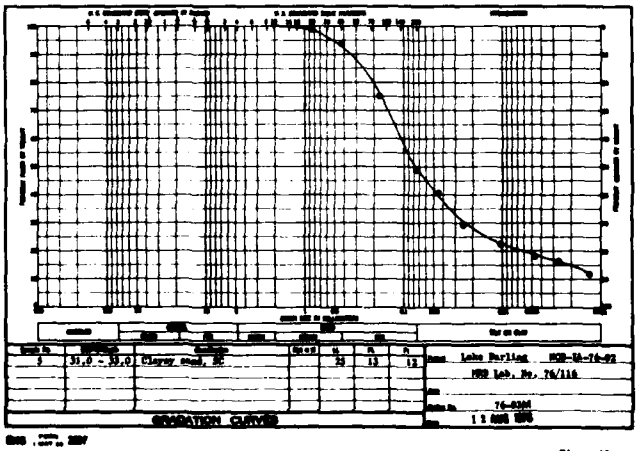


Figure 13

③

	SPECIMEN NUMBER	1	2	3
INITIAL	WATER CONTENT,%	31.9	31.6	32.6
	DRY DENSITY,PCF	89.3	91.3	90.3
	SATURATION,%	100+	100+	100+
	VOID RATIO	.84	.84	.86
BEFORE SHEAR	WATER CONTENT,%	32.0	31.1	31.6
	DRY DENSITY,PCF	89.5	91.5	90.5
	SATURATION,%	98	100	99
	VOID RATIO	.84	.84	.84
FINAL BACK PRESSURE,TSF		.00	.00	.00
MINOR PRINCIPAL STRESS,TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS,TSF		.95	.88	.86
TIME TO MAX DEV,HR		.24	.24	.24
ULT DEVIATOR STRESS,TSF		.89	.88	.86
INITIAL DIAMETER,IN		1.428	1.418	1.428
INITIAL HEIGHT,IN		2.953	2.946	2.943

AXIAL STRAIN,%

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Lean clay, CL

LL 45 PL 19 PI 26 Gs= 2.70 TYPE SPECIMEN: UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2089

Brittle gray structure, medium consistency, insensitive. Medium strength at PL, dull shine, no shake reaction.

PROJECT: Lake Darling NDS-38-76-02

BORING NO: 76-93M SAMPLE NO: 4

DEPTH: 25.0 - 27.0

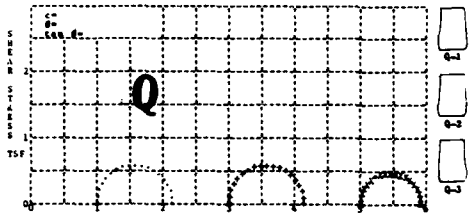
MRD LAB NO:76/116 DATE 12 AUG 76

TRIAXIAL COMPRESSION TEST REPORT

PLATE 10

②

* SEE NOTE PLATE B-49



	SPECIMEN NUMBER	1	2	3
INITIAL	WATER CONTENT,%	22.8	22.1	22.4
	DRY DENSITY,PCF	103.4	103.3	103.6
	SATURATION,%	100+	100+	100+
	VOID RATIO	.56	.56	.56
BEFORE SHEAR	WATER CONTENT,%	19.6	19.6	20.8
	DRY DENSITY,PCF	105.6	105.3	103.6
	SATURATION,%	93	91	96
	VOID RATIO	.56	.56	.58
FINAL BACK PRESSURE,TSF		.00	.00	.00
MINOR PRINCIPAL STRESS,TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS,TSF		1.13	1.13	.93
TIME TO MAX DEV,HR		.29	.28	.33
ULT DEVIATOR STRESS,TSF		1.13	1.13	.93
INITIAL DIAMETER,IN		1.397	1.398	1.400
INITIAL HEIGHT,IN		2.996	3.005	3.004

AXIAL STRAIN,%

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Clayey sand, SC

LL 28 PL 13 PI 12 Gs= 2.63 TYPE SPECIMEN: UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2089

Gray, brittle structure, medium consistency, insensitive. Low strength at PL, dull shine, fast shake reaction.

PROJECT: Lake Darling NDS-38-76-02

BORING NO: 76-93M SAMPLE NO: 5

DEPTH: 31.0 - 33.0

MRD LAB NO:76/116 DATE 12 AUG 76

TRIAXIAL COMPRESSION TEST REPORT

PLATE 12

④

DESIGN MEMORANDUM NO. 5 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

SOILS TEST DATA
LAKE DARLING DAM

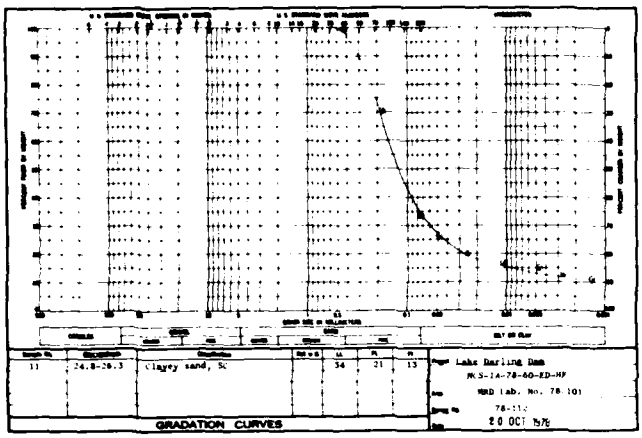
BORING 76-93 M

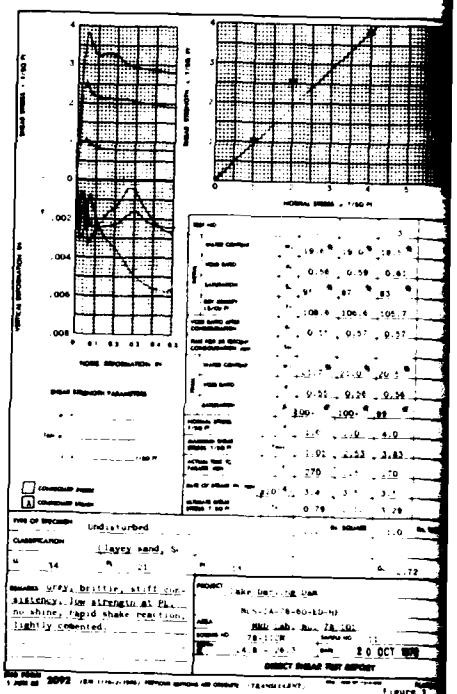
ST PAUL, MINN DISTRICT

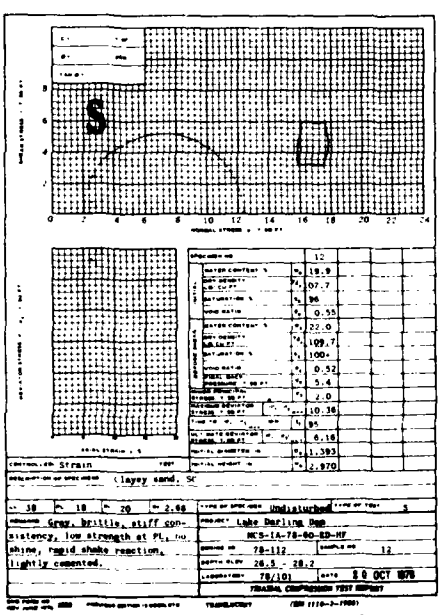
AUG 1983

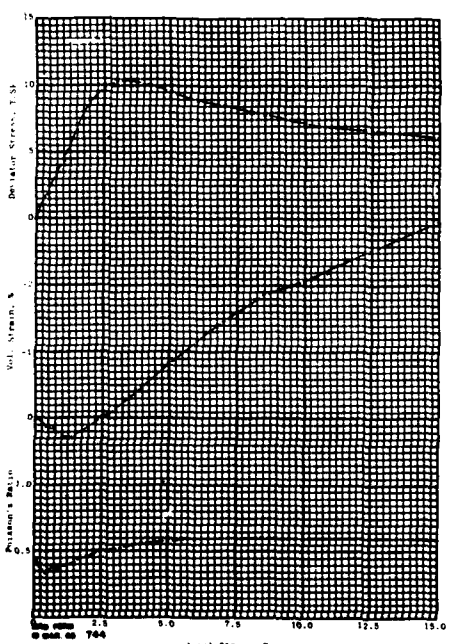
RI-R-5/788

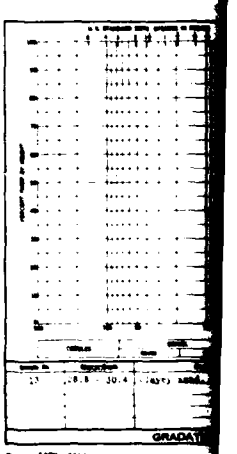
PLATE NDS-39


Lake Darling Dam
NCS-IA-78-60-ED-HF
NRD Lab. No. 78-101
78-112
20 OCT 1978
GRADATION CURVES


Undisturbed
Clayey sand, SC
Lake Darling Dam
NCS-IA-78-60-ED-HF
NRD Lab. No. 78-101
20 OCT 1978
DIRECT SHEAR TEST REPORT


Clayey sand, SC
Undisturbed
Lake Darling Dam
NCS-IA-78-60-ED-HF
78-112
78/101
20 OCT 1978
TRIAXIAL COMPRESSION TEST REPORT


Deviator Stress, T/SF
Vol. Strain, %
Axial Strain, %



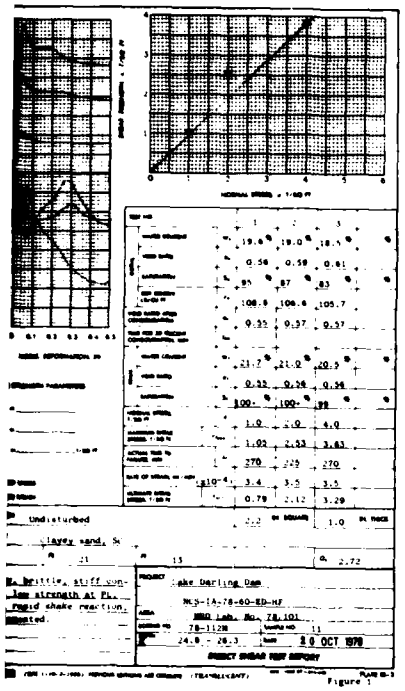


Figure 1

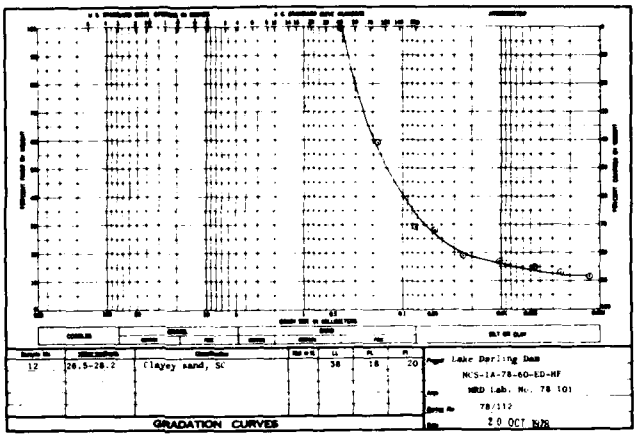


Figure 5

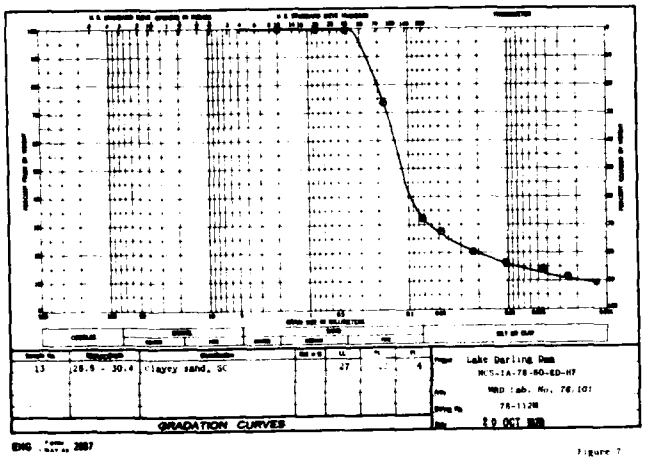


Figure 7

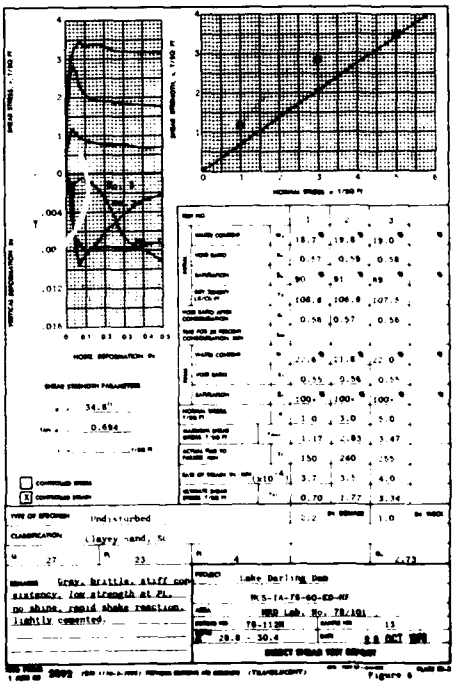


Figure 6

DESIGN MEMORANDUM NO. 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

SOILS TEST DATA
LAKE DARLING DAM

BORING 78-112 M

ST PAUL, MINN. DISTRICT

JUNE 1983

RI-R-S/759 PLATE NO. B-60

1 2

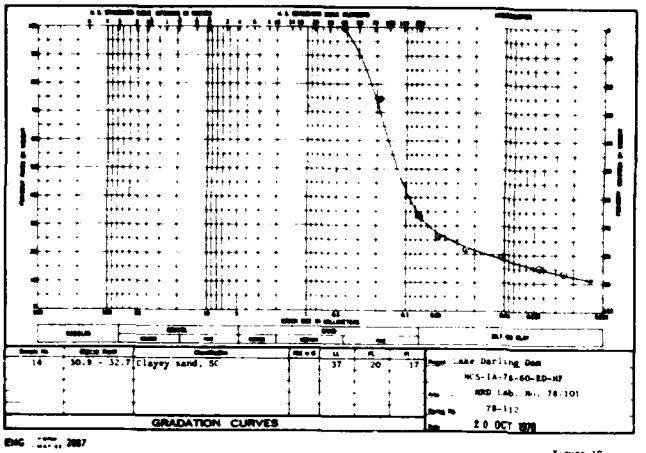
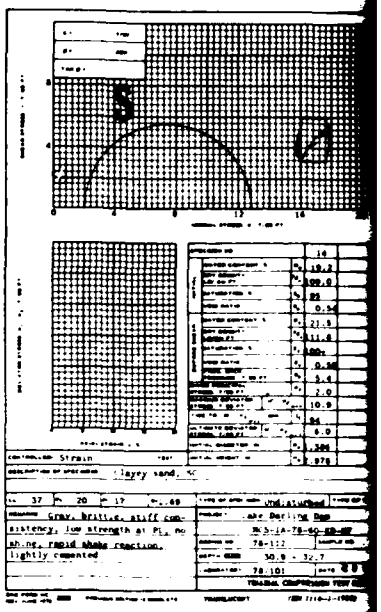


Figure 10



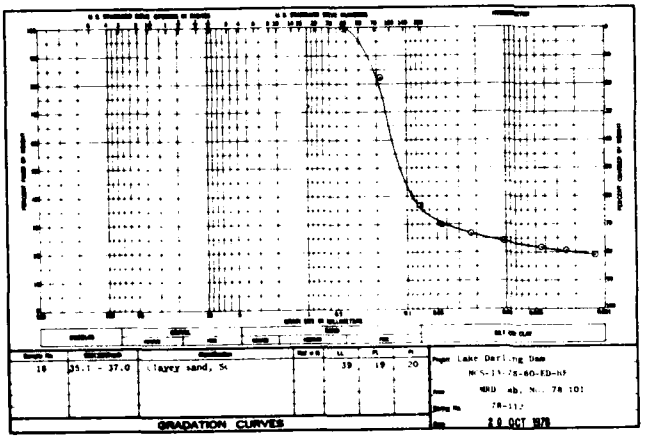
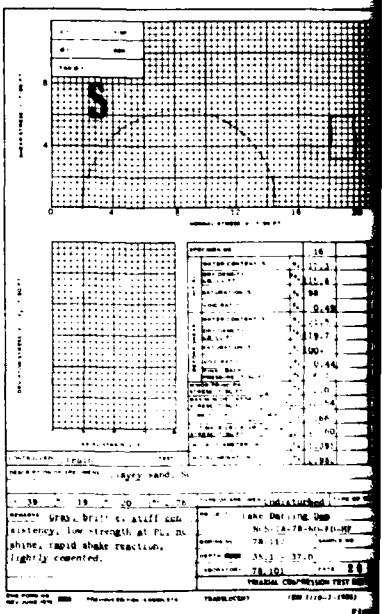


Figure 13



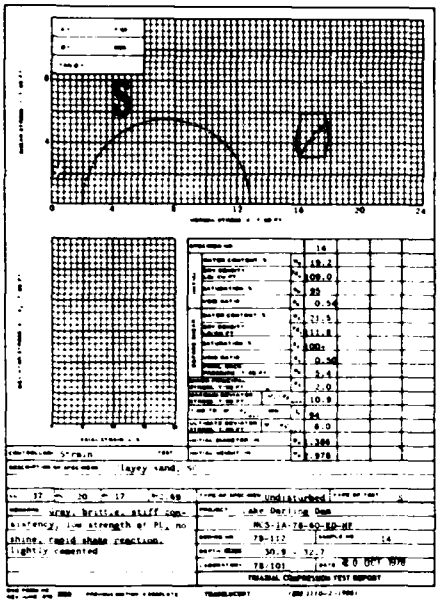


Figure 8

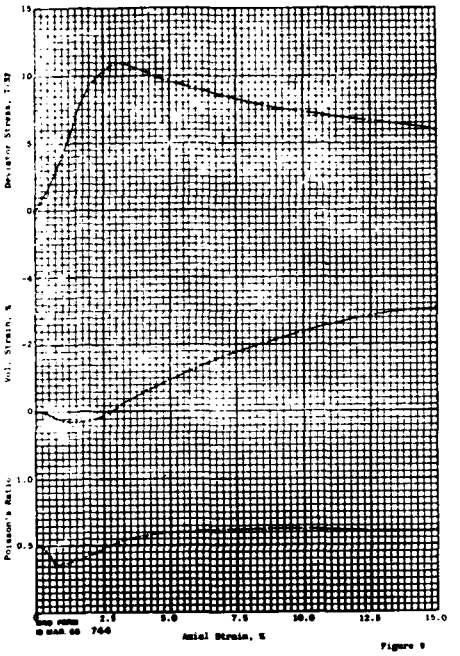


Figure 9

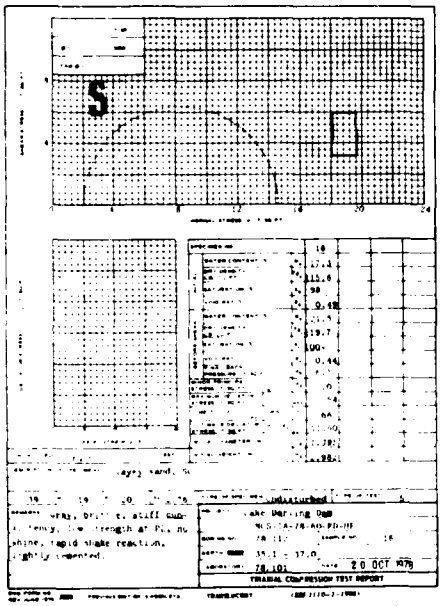


Figure 11

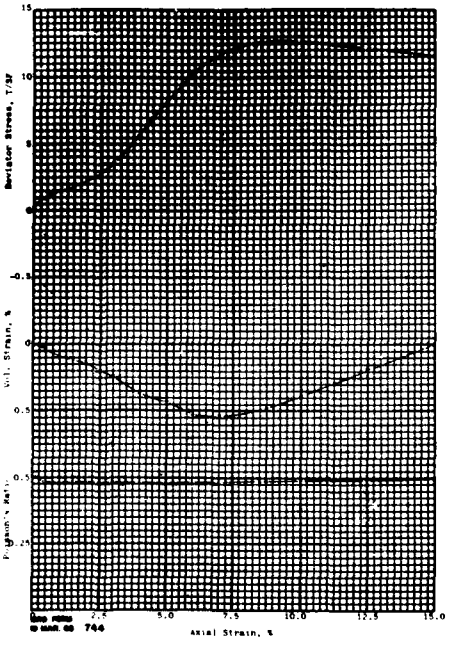


Figure 12

DESIGN MEMORANDUM NO. 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

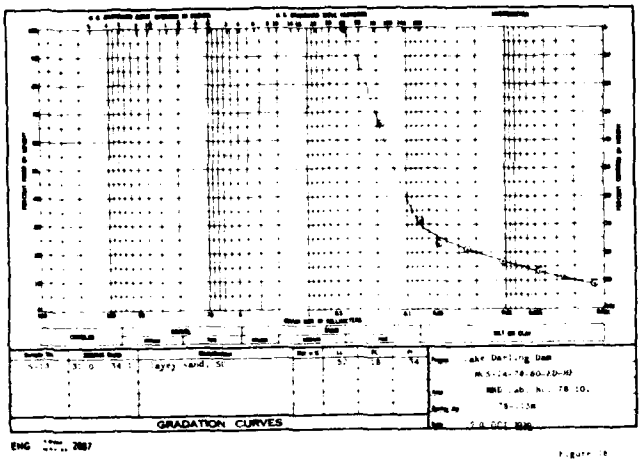
SOILS TEST DATA
LAKE DARLING DAM

BORING 78-112 M

ST PAUL, MINN DISTRICT

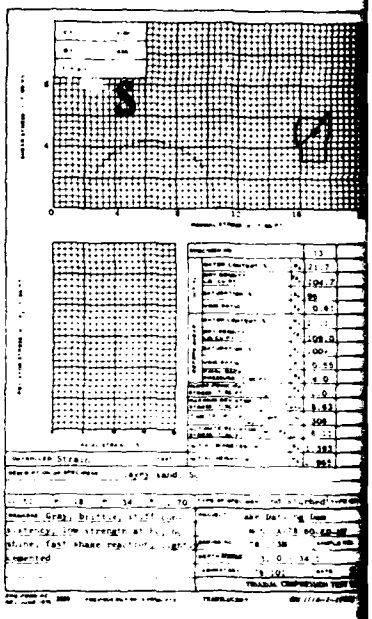
JUNE 1983

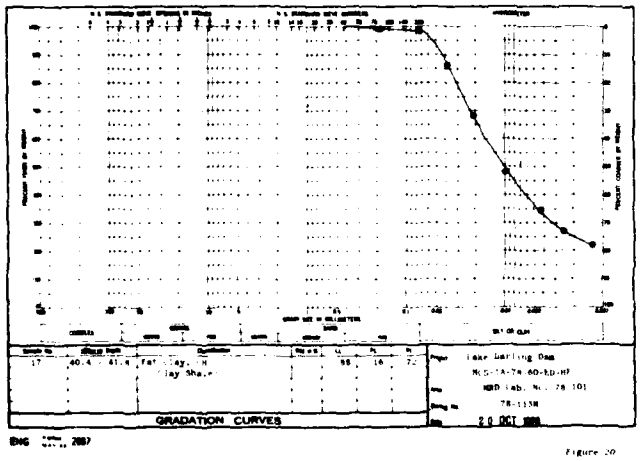
RI-R-S/760 PLATE NO.B-61



ENG

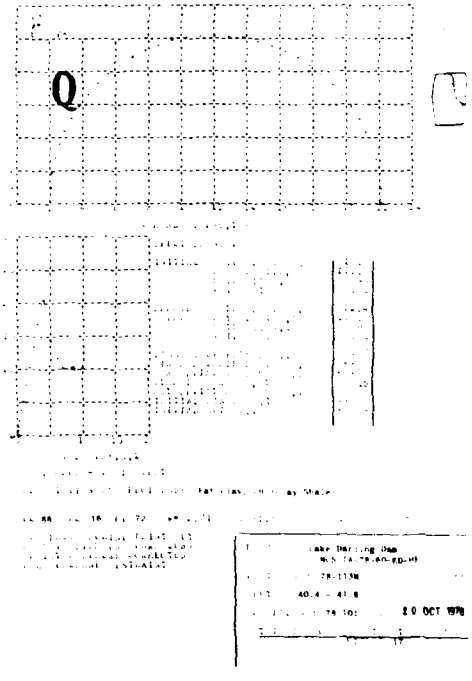
Figure 8

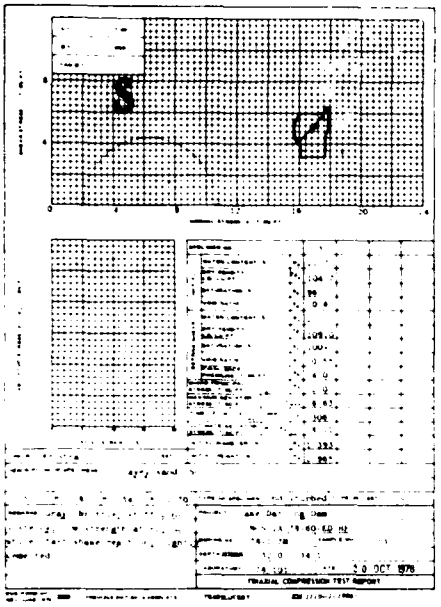


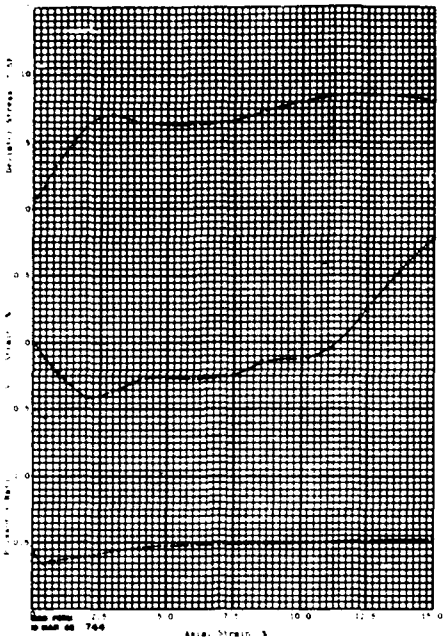


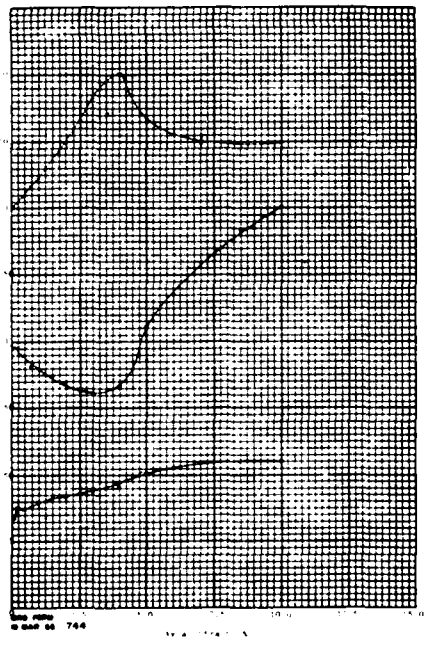
ENG

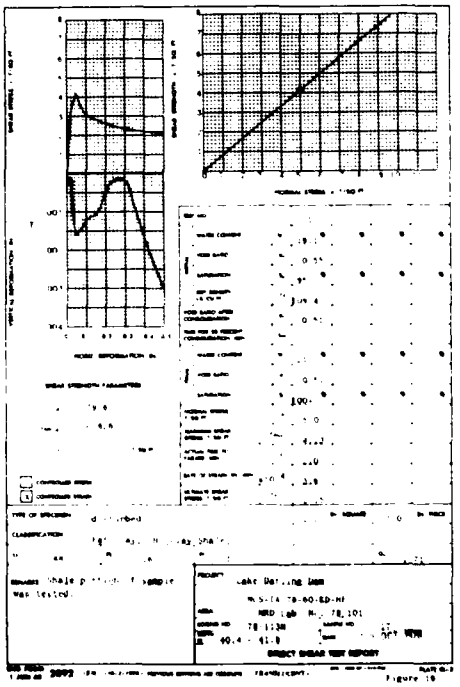
Figure 20











DESIGN MEMORANDUM NO. 3 GENERAL

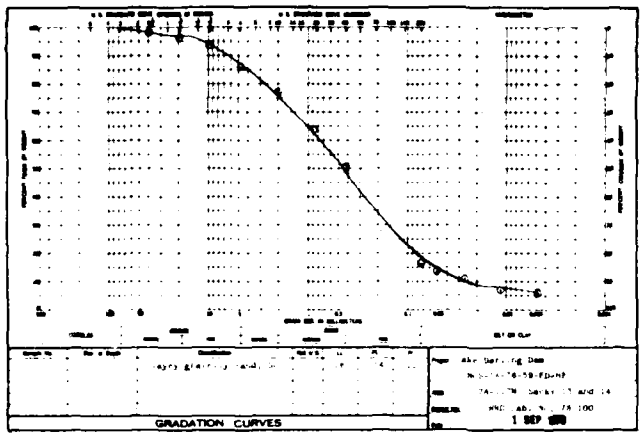
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

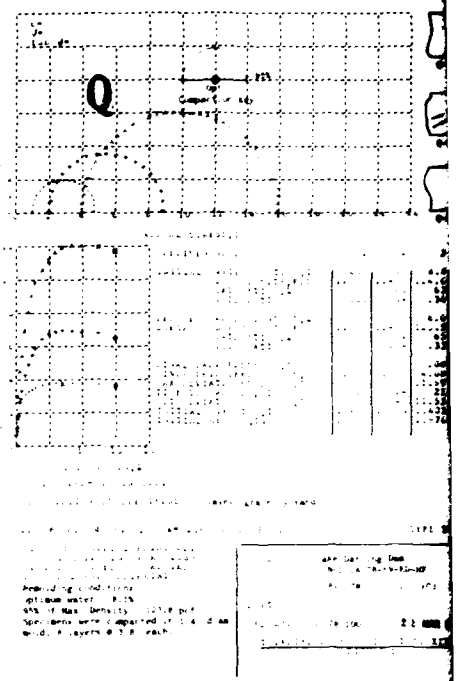
SOILS TEST DATA
LAKE DARLING DAM

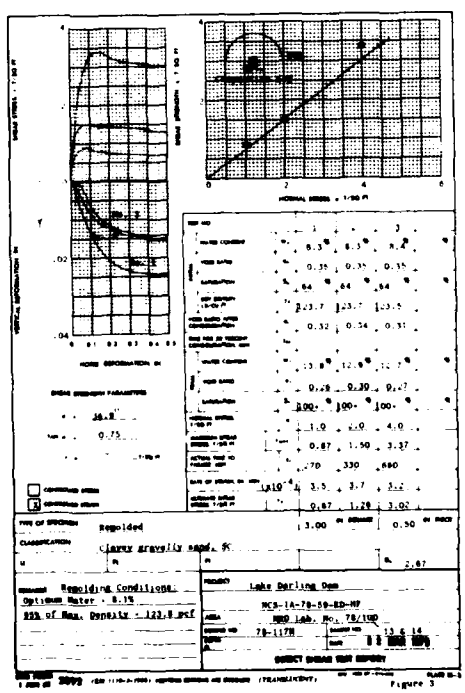
BORING 78-113M

ST PAUL, MINN DISTRICT

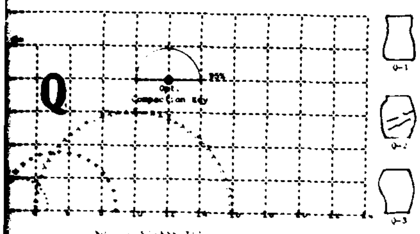
JUNE 1983

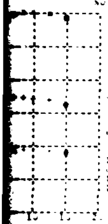

GRADATION CURVES


Q


Remolded
Clayey gravelly sand, SC
Remolding Conditions:
Optimum Water = 8.1%
95% of Max. Density = 122.8 pcf
Lake Darling Dam
MRD Lab. No. 78/100
78-117R

U. S. ARMY





Elev.: 13 & 14

Clayey gravelly sand, SC

PROJECT: Lake Darling Dam
NCS-IA-78-59-ED-HF

BORING NO.: 78-117M SAMPLE NO.: 13 & 14

DEPTH:

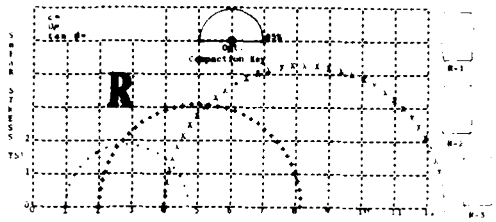
LAB. NO.: 78 100 DATE: 22 MAR 1979

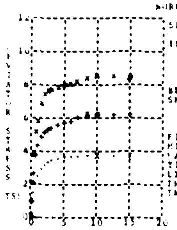
TRIAXIAL COMPRESSION TEST REPORT

Optimum Water = 8.1%

95% of Max. Density = 123.8 pcf

Specimens were compacted in 1.4" diam. mold, 8 layers @ 3/8" each.





CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Clayey gravelly sand, SC

LL 26 PL 14 PI 12 Gs 2.67 TYPE SPECIMEN REMOLDED TYPE TEST R

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2089 DEVIATOR STRESS CORRECTED FOR MEMBRANE RESTRAINT

Remolding Conditions.

Optimum Water = 8.1%

95% of Max. Density = 123.8 pcf

Specimens were compacted in 1.4" diam. mold, 8 layers @ 3/8" each.

B Value = 1.00

PROJECT: Lake Darling Dam
NCS-IA-78-59-ED-HF

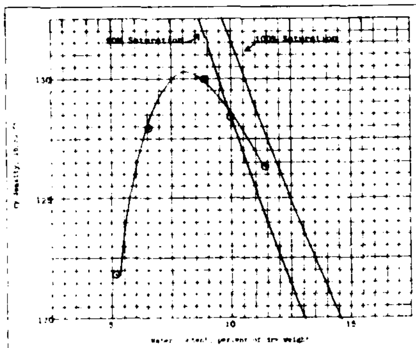
BORING NO.: 78-117M SAMPLE NO.: 13 & 14

DEPTH:

LAB. NO.: 78 100 DATE: 22 MAR 1979

TRIAXIAL COMPRESSION TEST REPORT

FIGURE 2



EM 1110-2-1906 compaction test

55 blows per each of 3 layers, with 5.5 lb rammer and 12 inch drop. 6.0 inch diameter mold

Sample No.	Elev or Depth	Classification	G	LL	PL	% > No. 4	% > 3/4 in
		Clayey gravelly sand, SC	2.67	26	14	15.0	2.5

Sample No.				
Natural water content, percent				
Optimum water content, percent	8.1			
Max dry density, lb/cu ft	130.3			

Remarks: Hole 78-117M Composite of Sacks 13 and 14

Project: Lake Darling Dam
NCS-IA-78-59-ED-HF

Area: NED Lab. No. 78/100

Boring No.

Date: 1 SEP 1978

COMPACTION TEST REPORT

ENG FORM 2091 — PREVIOUS EDITIONS ARE OBSOLETE — PLATE VI-8

Figure 1

DESIGN MEMORANDUM NO. 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

SOILS TEST DATA
LAKE DARLING DAM

BORING 78-117M

ST PAUL, MINN. DISTRICT

JUNE 1983

RI-R-S/762

1 2

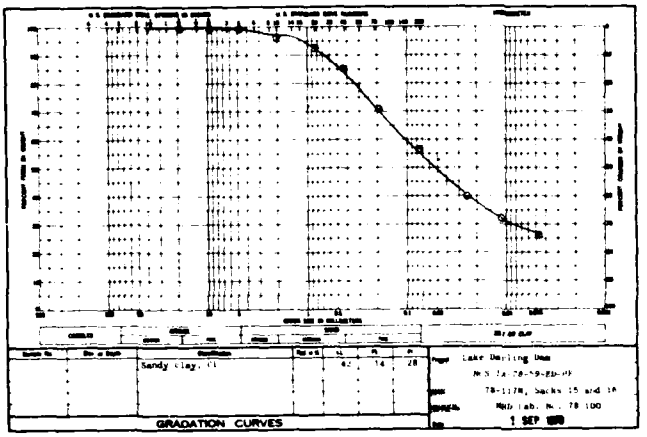
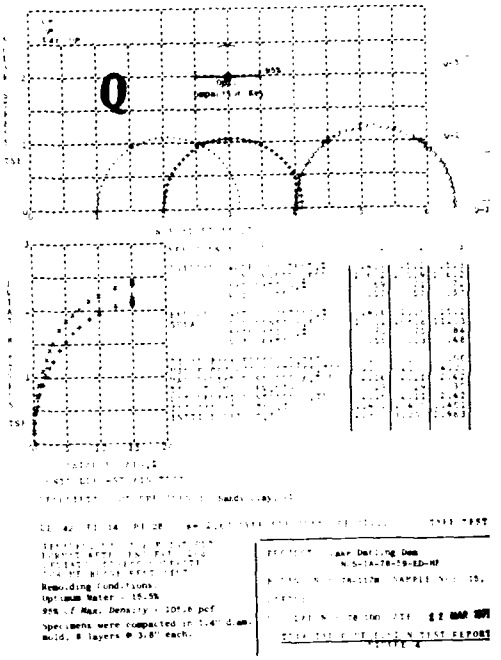


Figure 4



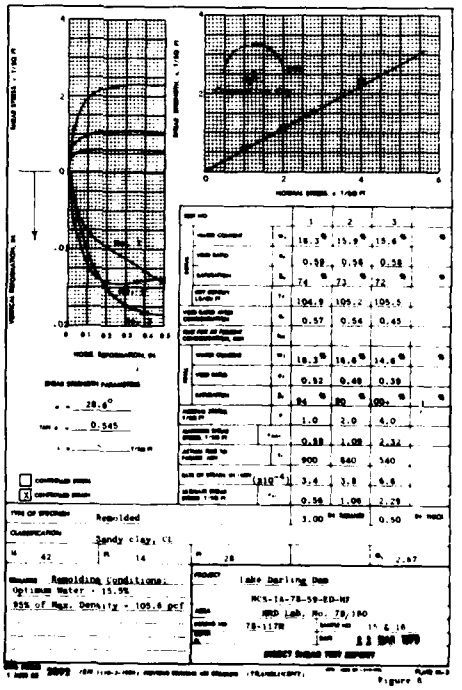
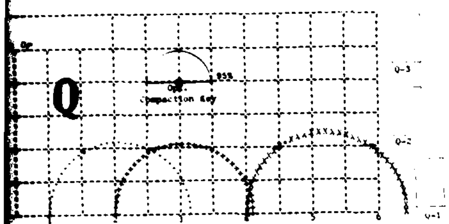
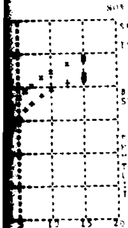


Figure 5

Q



NORMAL STRESS, TSF



SPECIMEN NO.		1	2	3
INITIAL	WATER CONTENT, %	14.7	15.2	15.3
	DRY DENSITY, PCF	106.2	105.9	106.2
	SATURATION, %	69	71	72
	VOID RATIO	.57	.57	.57
BEFORE SHEAR	WATER CONTENT, %	14.6	15.0	15.2
	DRY DENSITY, PCF	107.2	108.6	112.3
	SATURATION, %	70	75	84
	VOID RATIO	.55	.53	.48
	FINAL BACK PRESSURE, TSF	.00	.00	.00
	MINOR PRINCIPAL STRESS, TSF	1.00	2.00	4.00
	MAX DEVIATOR STRESS, TSF	2.16	2.11	2.42
	TIME TO MAX DEV, MIN	29	29	33
	ULT DEVIATOR STRESS, TSF	2.16	2.11	2.42
	INITIAL DIAMETER, IN	1.402	1.400	1.401
	INITIAL HEIGHT, IN	2.993	3.000	2.983

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

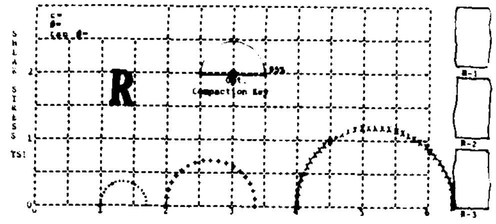
LL 42 PL 14 PI 28 Gs = 2.67 TYPE SPECIMENS: REMOLDED TYPE TEST Q

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2089 DEVIATOR STRESS CORRECTED FOR MEMBRANE RESTRAINT
Remolding Conditions:
Optimum Water = 15.5%
95% of Max. Density = 105.6 pcf
Specimens were compacted in 1.4" diam. mold, 8 layers @ 3/8" each.

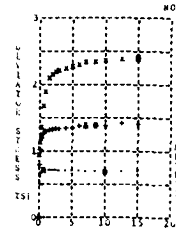
PROJECT: Lake Darling Dam
NCS-IA-78-39-ED-MF
BORING NO: 78-117M SAMPLE NO: 15, 16
DEPTH:
MRD LAB NO: 78/100 DATE 12 MAR 1979

TRIAXIAL COMPRESSION TEST REPORT
FIGURE 4

R



NORMAL STRESS, TSF



SPECIMEN NO.		1	2	3
INITIAL	WATER CONTENT, %	[illegible]	[illegible]	15.3
	DRY DENSITY, PCF	105.4	[illegible]	[illegible]
	SATURATION, %	71	71	71
	VOID RATIO	.56	.56	.56
BEFORE SHEAR	WATER CONTENT, %	[illegible]	[illegible]	[illegible]
	DRY DENSITY, PCF	[illegible]	113.9	[illegible]
	SATURATION, %	100+	100+	100+
	VOID RATIO	[illegible]	.46	[illegible]
	FINAL BACK PRESS., TSF	5.04	5.04	5.04
	MINOR PRINCIPAL STRESS, TSF	1.00	2.00	4.00
	MAX DEVIATOR STRESS, TSF	.71	1.37	2.39
	TIME TO MAX DEV, MIN	7	56	113
	ULT DEVIATOR STRESS, TSF	.68	1.37	2.39
	INITIAL DIAMETER, IN	1.403	1.403	1.403
	INITIAL HEIGHT, IN	2.995	2.999	2.994

CONTROLLED-STRAIN TEST

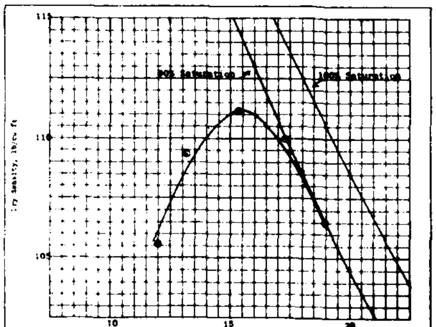
DESCRIPTION OF SPECIMENS: Sandy clay, CL

LL 42 PL 14 PI 28 Gs = 2.67 TYPE SPECIMENS: Remolded TYPE TEST R

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2089 DEVIATOR STRESS CORRECTED FOR MEMBRANE RESTRAINT
Remolding Conditions:
Optimum Water = 15.5%
95% of Max. Density = 105.6 pcf
Specimens were compacted in 1.4" diam. mold, 8 layers @ 3/8" each.
B Value = 0.99

PROJECT: Lake Darling Dam
BORING NO: 78-117M SAMPLE NO: 15 & 16
DEPTH:
MRD LAB NO: 78/100 DATE 13 MAR 1979

TRIAXIAL COMPRESSION TEST REPORT
FIGURE 5



Water content, percent of dry weight

EM 1110-2-1906 compaction test
25 blows per each of 3 layers, with 5.5 lb rammer and 12 inch drop. 4 inch diameter mold

Sample No.	Elev or Depth	Classification	G	LL	PL	% > No. 4	% > 3/4 in
		Sandy clay, CL	2.67	42	14	1.2	-

Sample No.				
Natural water content, percent				
Optimum water content, percent	15.6			
Max dry density, lb/cu ft	111.2			

Remarks: Hole 78-117M
Composite of Sacks 15 and 16

Project: Lake Darling Dam
NCS-IA-78-89-ED-MF
MRD Lab. No. 78/100
Boring No.
Date: 1 SEP 1978

COMPACTION TEST REPORT

ENG FORM 2087 — PLATE VI-9

Figure 3

DESIGN MEMORANDUM NO. 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

SOILS TEST DATA
LAKE DARLING DAM

BORING 78-117M

ST PAUL, MINN. DISTRICT

APR. 1983

RI-R-S/763

1 2

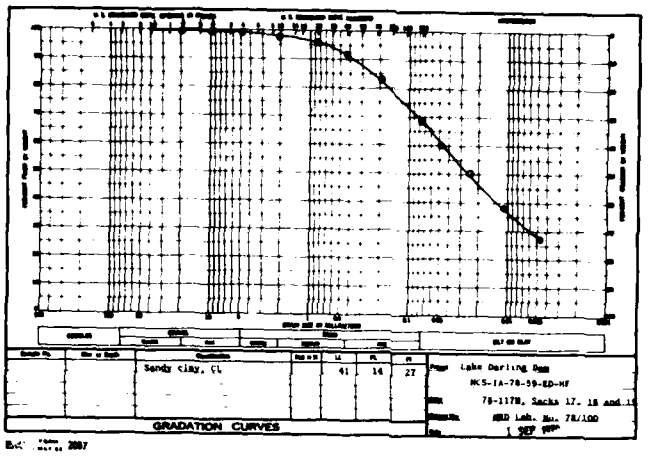
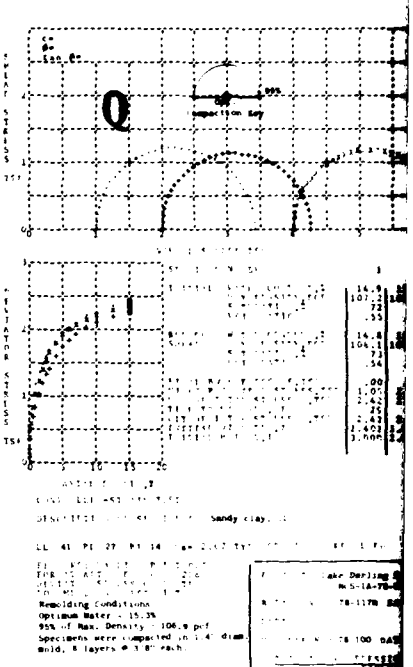
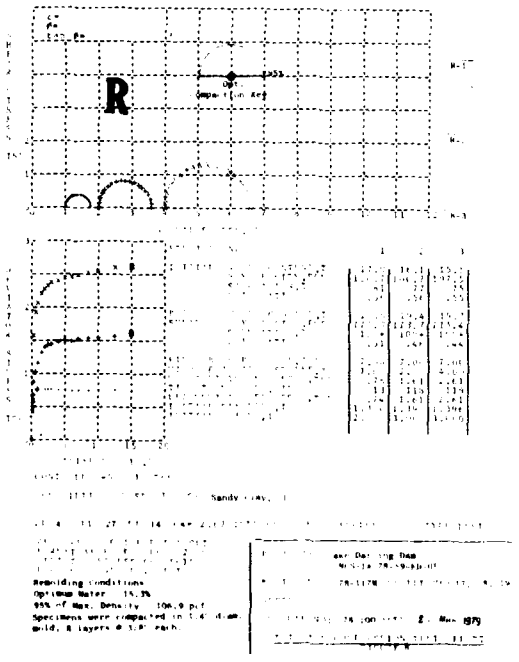
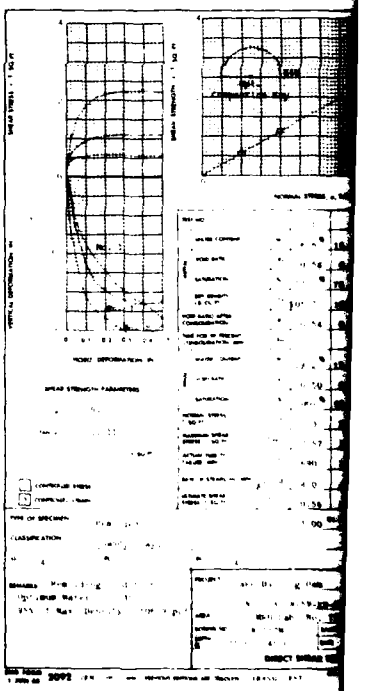

Sandy clay, CL
41
14
27
Lake Darling Dam
MKS-1A-78-59-ED-HF
78-1178, Sacks 17, 18 and 19
MRD Lab. No. 78/100
GRADATION CURVES

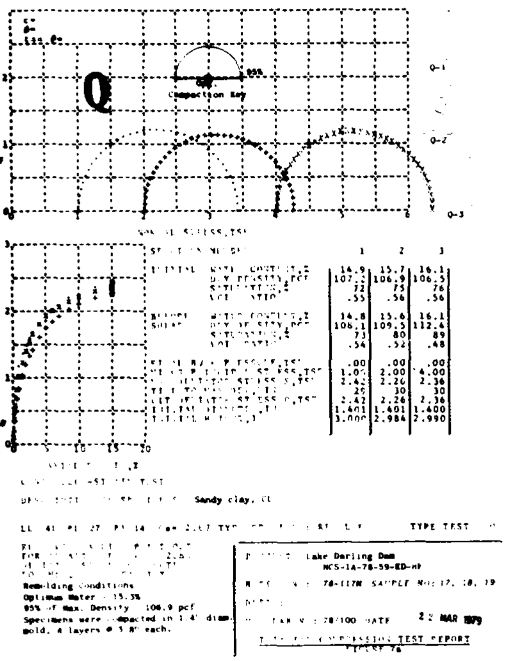
Figure 6

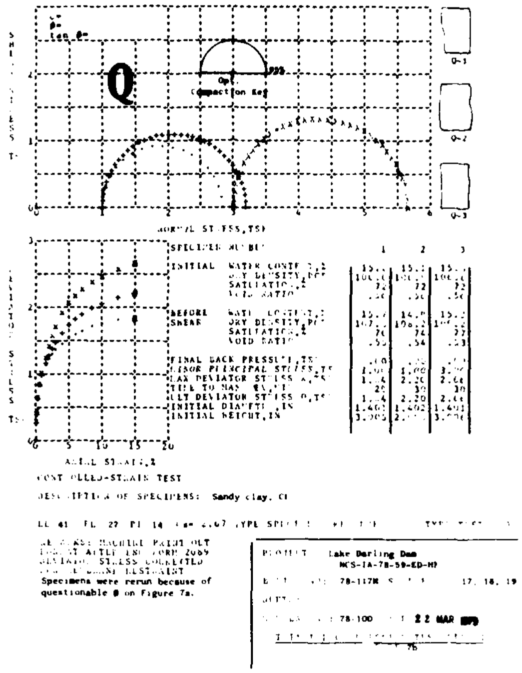

Remolding Conditions
Optimum Water - 15.3%
95% of Max. Density - 106.9 pcf
Specimens were compacted in 4" diam.
mold, 8 layers @ 3.8# each

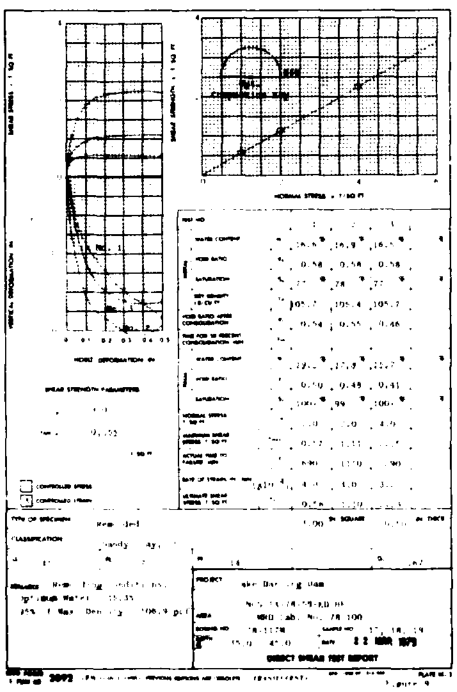

Remolding Conditions
Optimum Water - 15.3%
95% of Max. Density - 106.9 pcf
Specimens were compacted in 4" diam.
mold, 8 layers @ 3.8# each

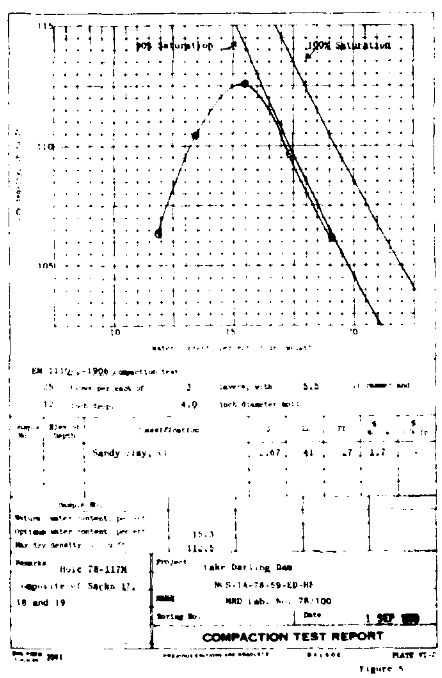


U. S. ARMY









DESIGN MEMORANDUM NO. 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

SOILS TEST DATA
LAKE DARLING DAM

BORING 78-117M

ST PAUL, MINN DISTRICT

JUNE 1983

RI-R-5/764

1 2

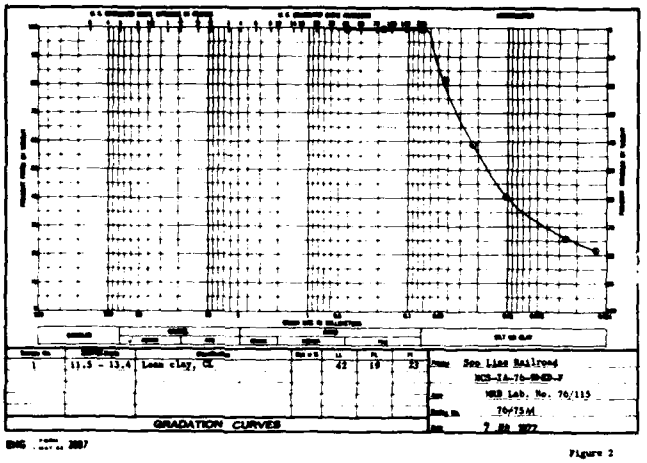
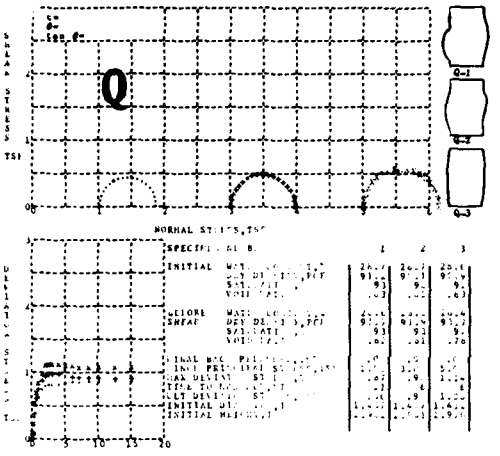


Figure 2

①



CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Lean clay, CL

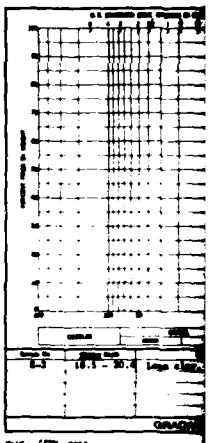
Brown, medium consistency, medium strength at PL, dull shine, slow shake reaction, brittle structure, no odor.

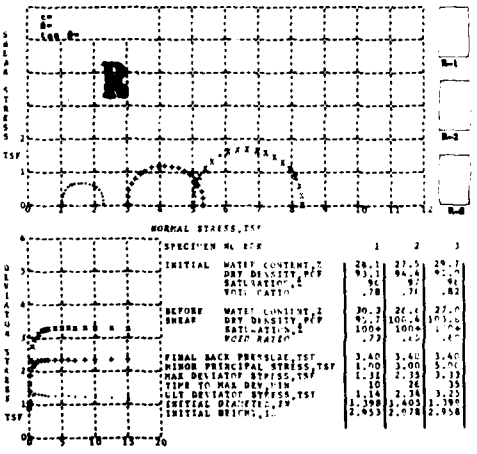
Torvane = 0.40 T/SF

Membrane correction applied to deviator stresses.

Soo Line Railroad
MSS-IA-76-89-ED-F
76-75M
11.5 - 13.4
76/115
7 JUL 1977

②





CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Lean clay, CL

LL 40 PL 17 PI 21 Gs= 2.66 TYPE SPECIMEN: UNDISTURBED TYPE TEST R

REMARKS: MACHINE PRINT OUT FORMAT AFTER MRD FORM 2089

R Value = 0.88

PROJECT: Soo Line Railroad
MSS-IA-76-89-ED-F
BORING NO: 76-75M SAMPLE NO: 2
DEPTH:
MRD LAB NO: 76/115 DATE 25 APR 1977
TRIAXIAL COMPRESSION TEST REPORT

⑤

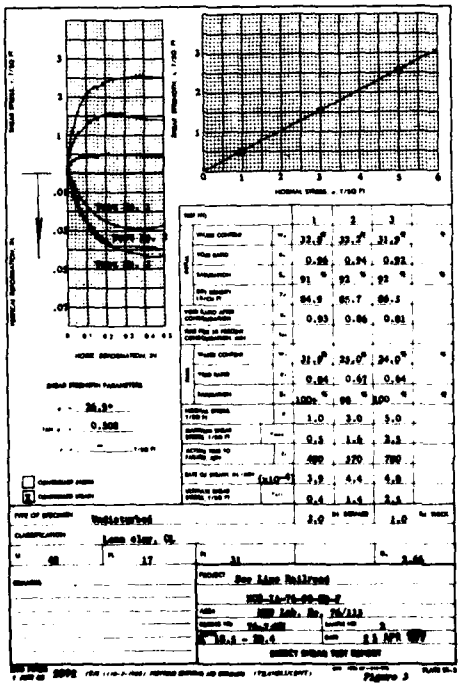
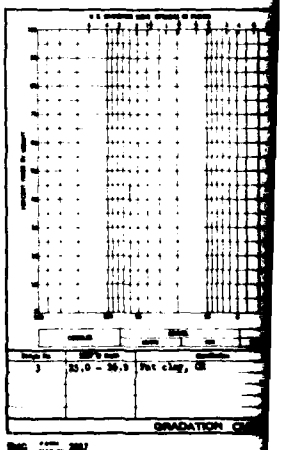
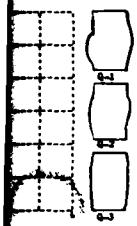


Figure 3

⑥





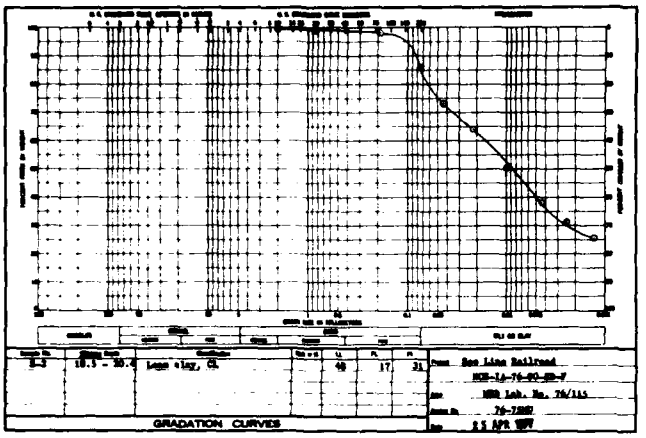
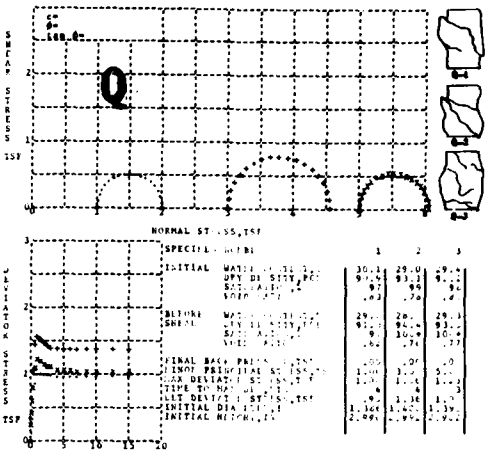


Figure 4

③



CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Lean clay,CL

LL 48 PL 17 PI 31 Gs= 2.65 TYPE SPECIMEN UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

Brown, medium consistency, medium strength at PL, dull shine, no shake reaction. Sample contained occasional silt lens.

PROJECT: Soo Line Railroad
MDR-IA-76-00-RR-F
BORING NO: 76-75M SAMPLE NO: 2
DEPTH: 18.5 - 20.5
MRD LAB NO: 76/115 DATE 25 APR 1977
TRIAXIAL COMPRESSION TEST REPORT

④

* SEE NOTE PLATE B-49

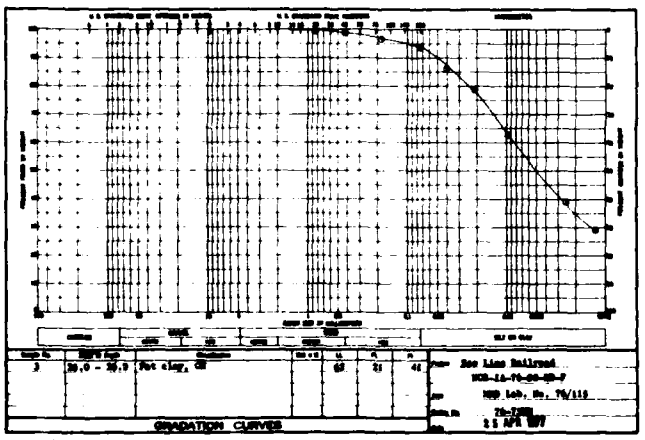
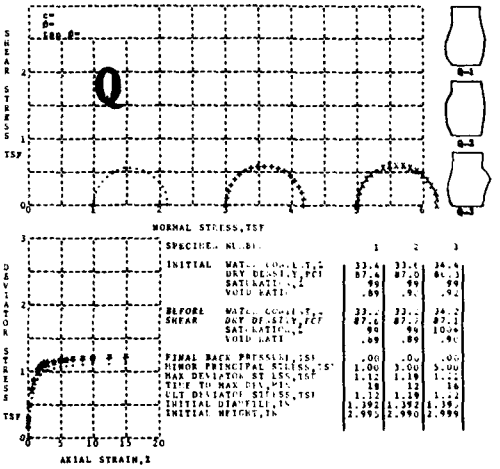


Figure 7

⑦



CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Fat clay, CH

LL 65 PL 31 PI 41 Gs= 2.65 TYPE SPECIMEN UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

Gray, soft to medium consistency, slightly sensitive, Med strength at PL, gloss shine, no shake reaction.

PROJECT: Soo Line Railroad
MDR-IA-76-00-RR-F
BORING NO: 76-7.5M SAMPLE NO: 3
DEPTH: 28.0 - 30.0
MRD LAB NO: 76/115 DATE 25 APR 1977
TRIAXIAL COMPRESSION TEST REPORT

⑧

DESIGN MEMORANDUM NO. 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
SOILS TEST DATA
SOO LINE RAILROAD
BORING 76-75 M
ST PAUL, MINN. DISTRICT
JUNE 1983

PLATE NO. B-66

RI-R-21788c

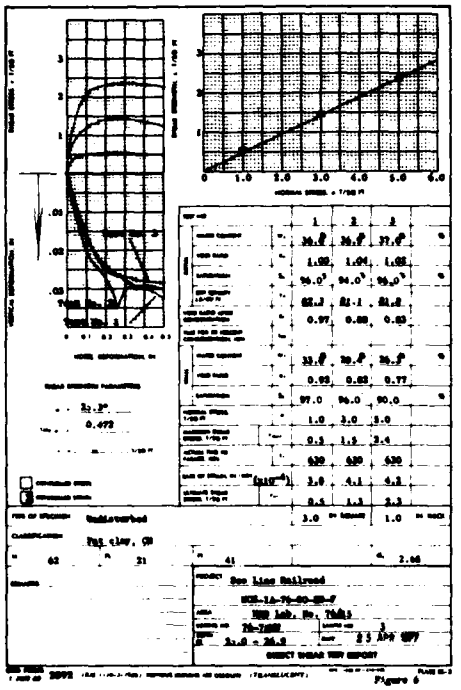


Figure 6

①

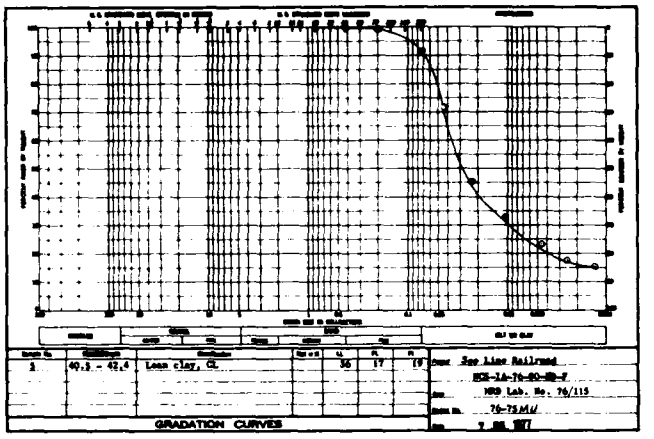


Figure 6

②

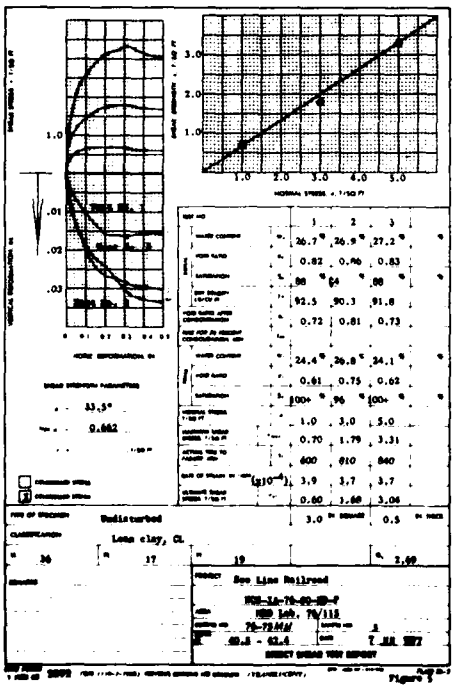


Figure 5

⑤

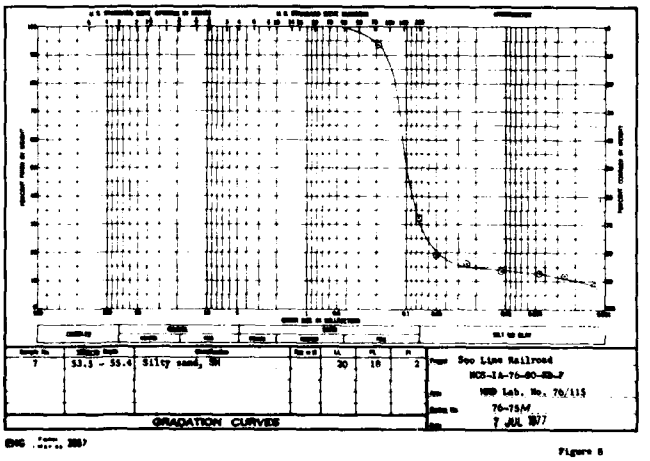


Figure 8

⑥

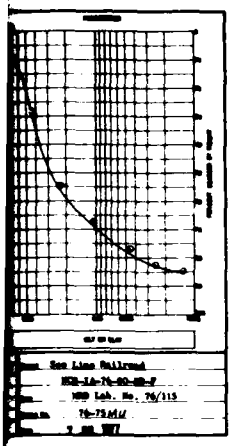
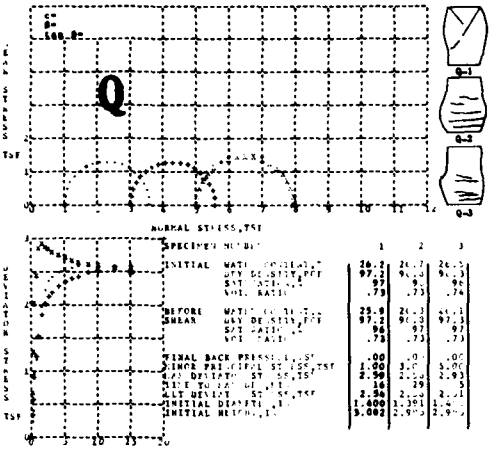


Figure 6



SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT,%	26.2	26.7	26.5
	DRY DENSITY,PCF	97.2	96.4	96.8
	SATURATION,%	97	96	96
	VOID RATIO	.73	.73	.74
BEFORE SHEAR	WATER CONTENT,%	25.8	26.3	26.1
	DRY DENSITY,PCF	97.2	96.3	97.3
	SATURATION,%	96	97	97
	VOID RATIO	.73	.73	.73
FINAL BACK PRESS.DI,TSF		.00	.0	.00
MINOR PRINCIPAL STRESS,TSF		1.00	3.0	5.00
MAX DEVIATOR STRESS,TSF		2.58	2.94	2.93
TIME TO MAX DEVIATOR,HR		.16	.19	.5
ULT DEVIATOR STRESS,TSF		2.58	2.94	2.93
INITIAL DIAMETER,IN		1.400	1.391	1.4
INITIAL HEIGHT,IN		5.882	2.975	2.9

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Loam clay, CL

LL 36 PL 17 PI 19 Gs= 2.69 TYPE SPECIMEN: UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2089

Brown, medium consistency, low strength at PL, dull shine, slow shake reaction, brittle structure, slightly sensitive.

Terrane = 0.58 T/SF

Deviator stresses not corrected for membrane restraint.

PROJECT: See Line Railroad MCR-1A-76-80-SB-F

BORING NO: 76-75MU SAMPLE NO: 5

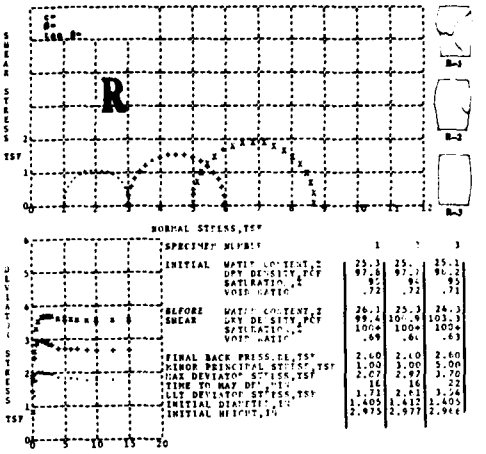
DEPTH: 40.5 - 42.4

MRD LAB NO: 76/115 DATE 7 JUL 1977

TRIAXIAL COMPRESSION TEST REPORT

PLATE B-5

③



SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT,%	25.3	25.	25.1
	DRY DENSITY,PCF	97.6	97.2	96.2
	SATURATION,%	92	96	93
	VOID RATIO	.72	.72	.73
BEFORE SHEAR	WATER CONTENT,%	26.1	25.3	24.3
	DRY DENSITY,PCF	99.4	100+	103.3
	SATURATION,%	100+	100+	100+
	VOID RATIO	.69	.64	.63
FINAL BACK PRESS.DI,TSF		2.60	2.60	2.60
MINOR PRINCIPAL STRESS,TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS,TSF		2.07	2.92	3.70
TIME TO MAX DEVIATOR,HR		.16	.16	.22
ULT DEVIATOR STRESS,TSF		1.71	2.61	3.24
INITIAL DIAMETER,IN		1.405	1.412	1.405
INITIAL HEIGHT,IN		2.975	2.977	2.966

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Loam clay, CL

LL 36 PL 17 PI 19 Gs= 2.69 TYPE SPECIMEN: UNDISTURBED TYPE TEST R

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2089

B Value = 1.00

PROJECT: See Line Railroad MCR-1A-76-80-SB-F

BORING NO: 76-75MU SAMPLE NO: 5

DEPTH: 40.5 - 42.4

MRD LAB NO: 76/115 DATE 7 JUL 1977

TRIAXIAL COMPRESSION TEST REPORT

PLATE B-6

④

*SEE NOTE PLATE B-49

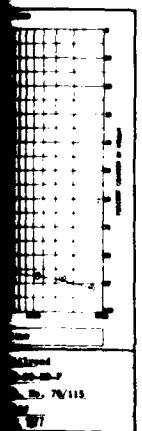
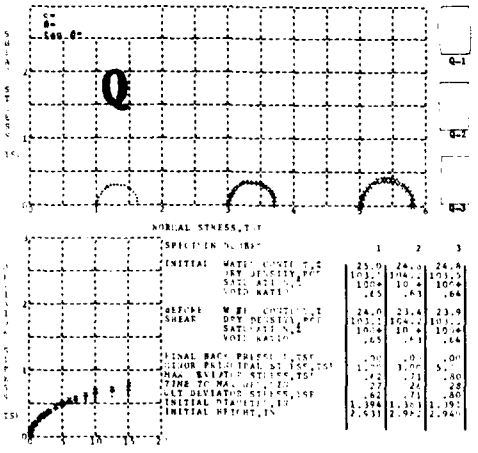


Figure 8



SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT,%	23.0	24.0	24.6
	DRY DENSITY,PCF	103.7	104.0	103.5
	SATURATION,%	100+	10.2	100+
	VOID RATIO	.65	.63	.64
BEFORE SHEAR	WATER CONTENT,%	24.0	23.4	23.9
	DRY DENSITY,PCF	103.5	104.2	103.6
	SATURATION,%	100+	10.2	10.2
	VOID RATIO	.65	.63	.64
FINAL BACK PRESS.DI,TSF		.00	.0	.00
MINOR PRINCIPAL STRESS,TSF		1.00	3.00	5.
MAX DEVIATOR STRESS,TSF		.62	.71	.80
TIME TO MAX DEVIATOR,HR		.02	.21	.28
ULT DEVIATOR STRESS,TSF		.62	.71	.80
INITIAL DIAMETER,IN		1.394	1.393	1.39
INITIAL HEIGHT,IN		2.651	2.643	2.64

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Silty sand, SM

LL 20 PL 18 PI 2 Gs= 2.72 TYPE SPECIMEN: DISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2089

Gray, soft consistency, very wet, low strength at PL, no shine, rapid shake reaction, brittle structure, insensitive, no odor.

PROJECT: See Line Railroad MCR-1A-76-80-SB-F

BORING NO: 76-75M SAMPLE NO: 7

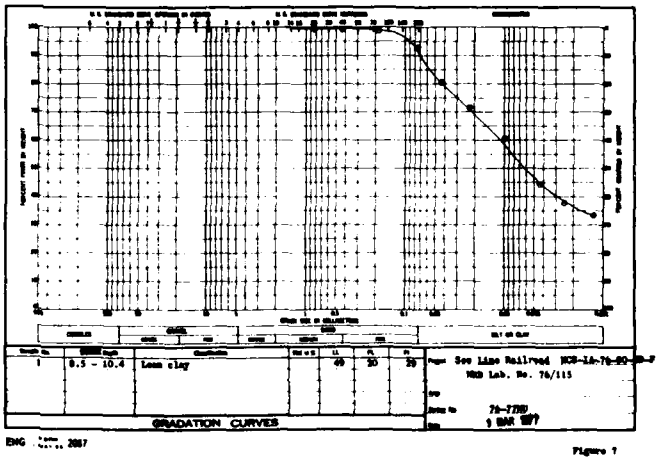
DEPTH: 53.5 - 55.4

MRD LAB NO: 76/115 DATE 7 JUL 1977

TRIAXIAL COMPRESSION TEST REPORT

PLATE B-7

⑦



ENG Form 2087

Figure 7

⑧

DESIGN MEMORANDUM NO. 5 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

SOILS TEST DATA
SOO LINE RAILROAD

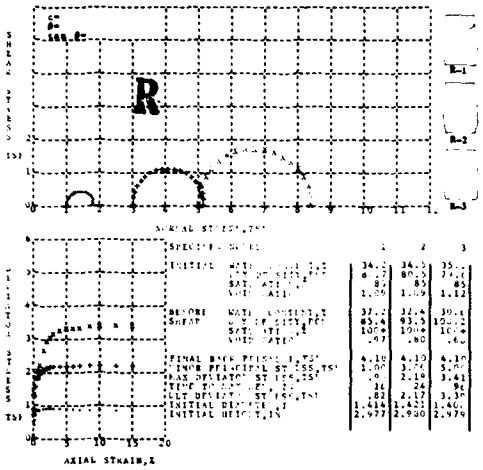
BORINGS 76-75M AND 76-77M

ST PAUL, MINN DISTRICT

JUNE 1983

RI-R-S/766

PLATE NO. B-67



AXIAL STRAIN, %

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Lean clay, CL

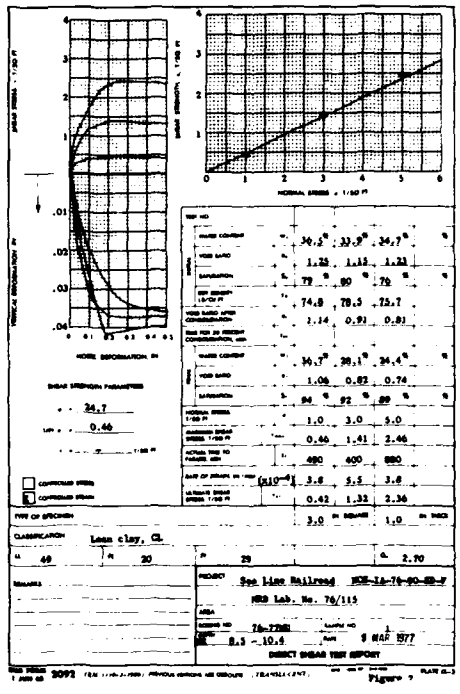
LL 40 PL 20 PI 20 Gs= 2.70 TYPE SPECIMEN: UNDISTURBED TYPE TEST R

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089
Brown, soft consistency, medium strength at PL, dull shine, no shake reaction.

B Value = 1.00
No material for "Q" tests.

PROJECT: See Line Railroad HDR-IA-76-90-RB-F
BORING NO: 76-T78B SAMPLE NO: 1 DEPTH: 8.5 - 10.4
HRD LAB NO: 76/115 DATE: 9 MAR 1977
TRIAXIAL COMPRESSION TEST REPORT

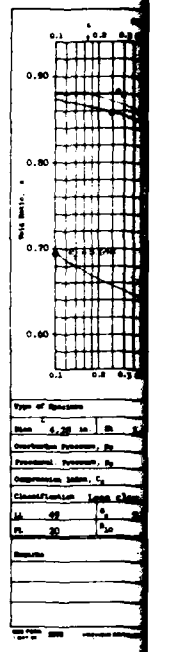
①

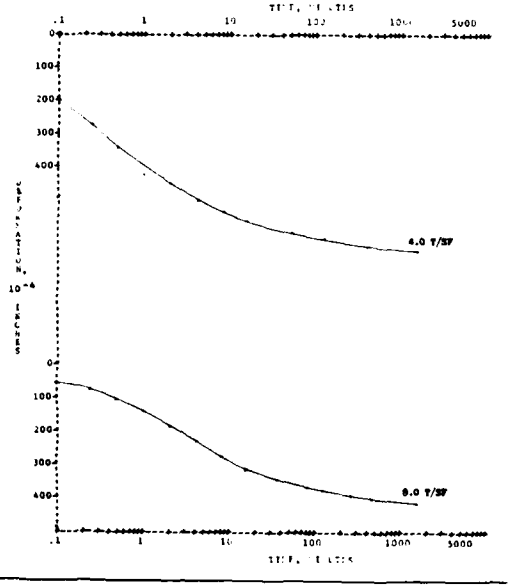


PROJECT See Line Railroad HDR-IA-76-90-RB-F
HRD Lab. No. 76/115
BORING NO. 76-T78B SAMPLE NO. 1
DEPTH 8.5 - 10.4 DATE 9 MAR 1977
DIRECT SHEAR TEST REPORT

Lean clay, CL
LL 40 PI 20 Gs 2.70

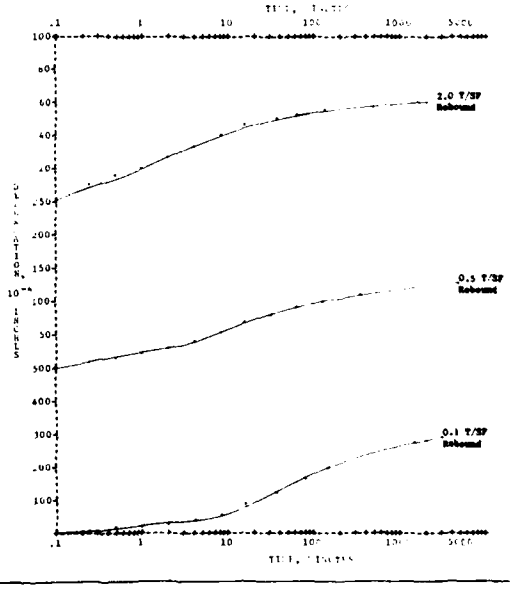
②





PROJECT: See Line Railroad HDR-IA-76-90-RB-F
HRD LABORATORY NO: 76/115
BORING NO: 76-T78B SAMPLE NO: 1 DEPTH: 8.5 - 10.4 DATE: 9 MAR 1977
CONSOLIDATION TEST -- TIME CURVES
MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

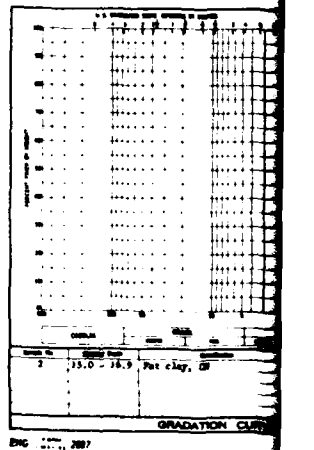
⑤

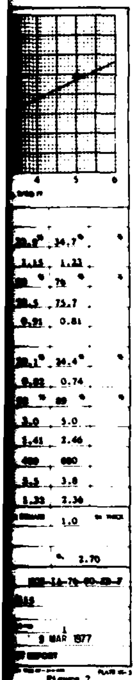


PROJECT: See Line Railroad HDR-IA-76-90-RB-F
HRD LABORATORY NO: 76/115
BORING NO: 76-T78B SAMPLE NO: 1 DEPTH: 8.5 - 10.4 DATE: 9 MAR 1977
CONSOLIDATION TEST -- TIME CURVES
MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

⑥

*SEE NOTE





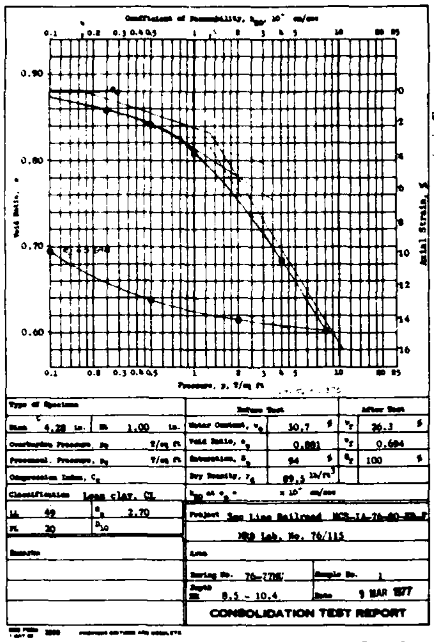


Figure 3

③

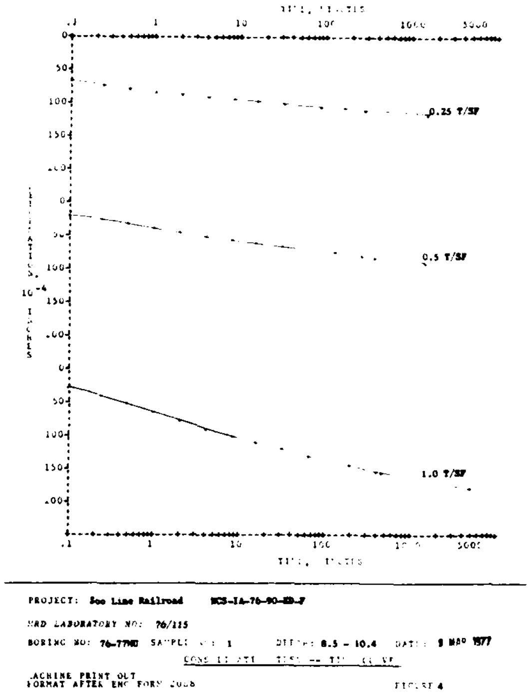


FIGURE 4

④

*SEE NOTE PLATE B-49

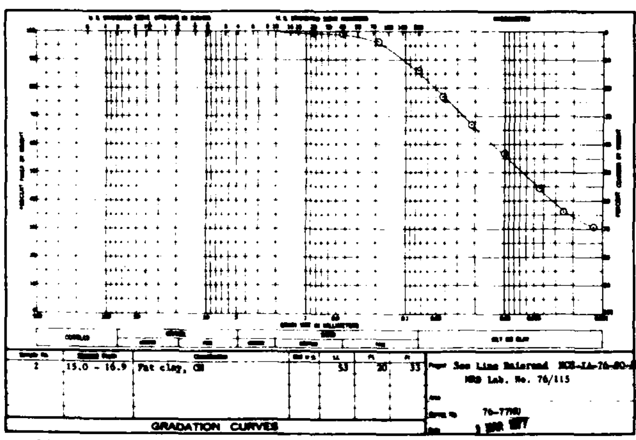
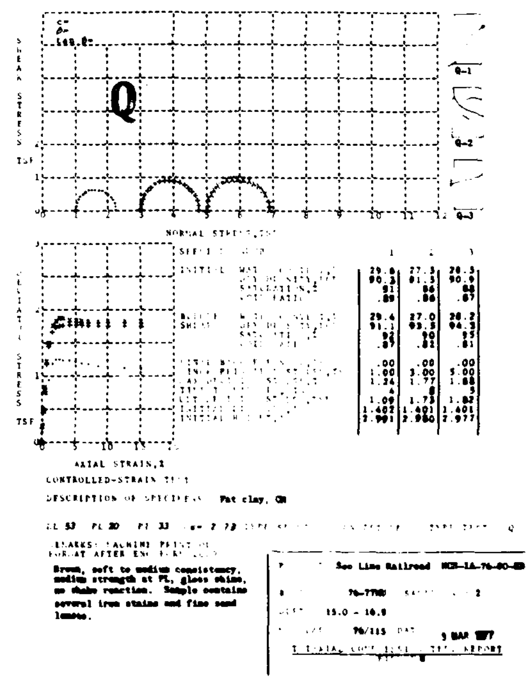


Figure 15

⑦



⑧

DESIGN MEMORANDUM NO. 3 GENERAL

FLOOD CONTROL – LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

SOILS TEST DATA
SOO LINE RAILROAD

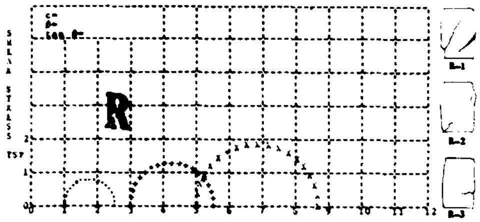
BORING 76-77 M

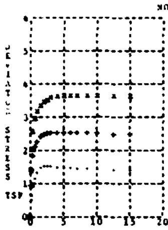
ST PAUL, MINN DISTRICT

JUNE 1983

RI-R-5/767

CORPS OF ENGINEERS





SPECIMEN [illegible]		1	2	3
INITIAL	WATER CONTENT, %	32.2	31.6	31.4
	DRY DENSITY, PCF	88.4	88.5	89.5
	SATURATION, %	95	94	95
	VOID RATIO	.93	.93	.90
BEFORE SHEAR	WATER CONTENT, %	34.2	26.1	26.7
	DRY DENSITY, PCF	91.2	96.5	[illegible]
	SATURATION, %	100+	100+	100+
	VOID RATIO	.87	.77	.70
FINAL BACK PRESSURE, TSF		4.00	4.00	4.80
MINOR PRINCIPAL STRESS, TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS, TSF		1.55	2.55	3.69
TIME TO MAX DEV, MIN		19	40	46
ULT DEVIATOR STRESS, TSF		1.39	2.48	3.63
INITIAL DIAMETER, IN		1.423	1.417	1.416
INITIAL HEIGHT, IN		2.966	2.964	2.973

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Fat clay, CH

LL 53 PL 20 PI 33 Gs= 2.73 TYPE SPECIMEN: [illegible] TYPE TEST R

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

B Value = 0.98

PROJECT: Soo Line Railroad
NCS-IA-76-80-ED-F

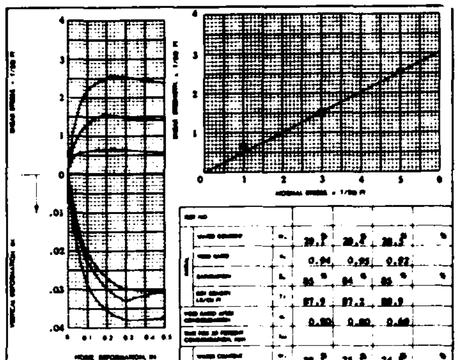
BORING NO: 76-77MU SAMPLE NO: 2

DEPTH: 15.0 - 16.9

NED LAB NO: 76/115 DATE: 9 MAR 1977

TRIAXIAL COMPRESSION TEST REPORT
FIGURE 9

①



SHEAR STRENGTH PARAMETERS

φ = 27.0

tan φ = 0.510

c = – T/SQ FT

☐ CONTROLLED STRESS
☒ CONTROLLED STRAIN

TEST NO.						
INITIAL	WATER CONTENT	w_o	29.7 %	28.4 %	28.5 %	%
	VOID RATIO	e_o	0.94	0.95	0.92	
	SATURATION	S_o	85 %	84 %	85 %	%
	DRY DENSITY LB/CU FT	γ_d	87.9	87.2	88.9	
VOID RATIO AFTER CONSOLIDATION		e_c	0.80	0.80	0.68	
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}				
FINAL	WATER CONTENT	w_f	30.7 %	25.7 %	24.5 %	%
	VOID RATIO	e_f	0.84	0.72	0.63	
	SATURATION	S_f	91 %	94 %	100 %	%
NORMAL STRESS T/SQ FT		σ	1.0	3.0	5.0	
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	0.65	1.52	2.55	
ACTUAL TIME TO FAILURE, MIN		t_f	660	600	720	
RATE OF STRAIN, IN./MIN (x10⁻⁴)			3.7	3.6	3.5	
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}	0.56	1.42	2.37	

TYPE OF SPECIMEN	3.0 IN. SQUARE	1.0 IN. THICK

CLASSIFICATION Fat clay, CH

LL 53	PL 20	PI 33		Gs 2.73

REMARKS

PROJECT Soo Line Railroad NCS-IA-76-80-ED-F

NED Lab. No. 76/115

AREA

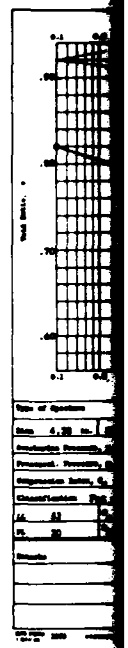
BORING NO. 76-77MU SAMPLE NO. 2

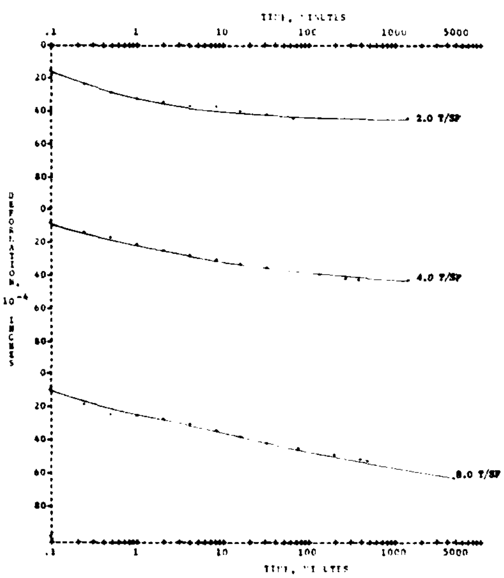
DEPTH, FT 15.0 - 16.9 DATE 9 MAR 1977

DIRECT SHEAR TEST REPORT

ENG FORM 1 JUN 68 2092 [illegible] (TRANSLUCENT) Figure 10 PLATE [illegible]

②





PROJECT: Soo Line Railroad NCS-IA-76-80-ED-F

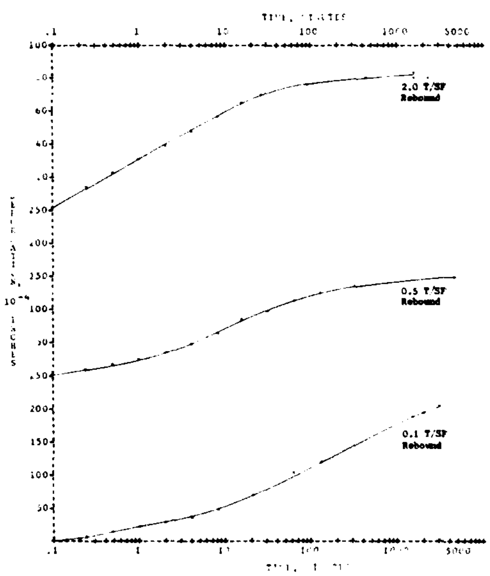
NED LABORATORY NO: 76/115

BORING NO: 76-77MU SAMPLE NO: 2 DEPTH: 15.0 - 16.9 DATE: 9 MAR 1977

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2086 FIGURE 13

⑤



PROJECT: Soo Line Railroad NCS-IA-76-80-ED-F

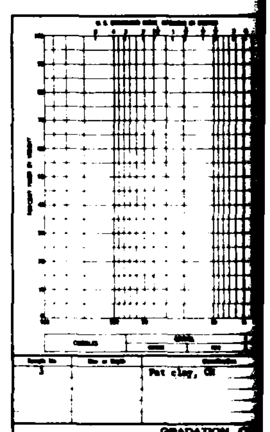
NED LABORATORY NO: 76/115

BORING NO: 76-77MU SAMPLE NO: 2 DEPTH: 15.0 - 16.9 DATE: 9 MAR 1977

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2086 FIGURE 14

⑥



ENG 2087

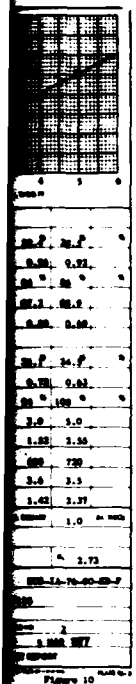
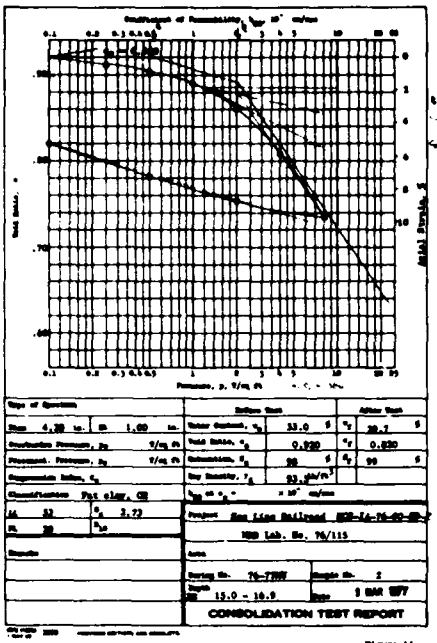


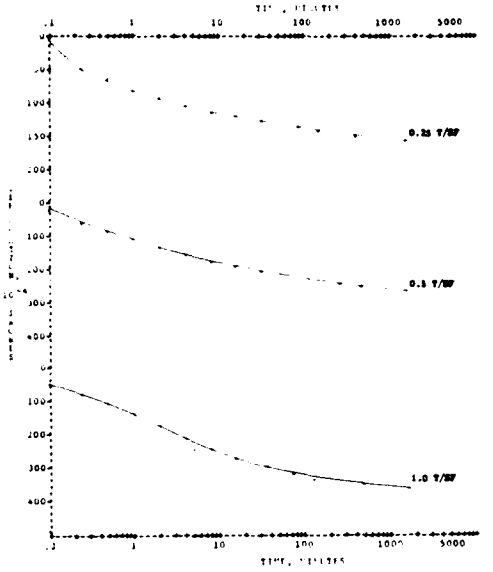
Figure 10



CONSOLIDATION TEST REPORT

Figure 11

③



PROJECT: Soo Line Railroad SOO-LA-76-00-SD-F

LAB LABORATORY NO: 76/115

BORING NO: 76-77M SAMPLE NO: 2 DEPTH: 13.0 - 16.9 DATE: 9 MAR 77

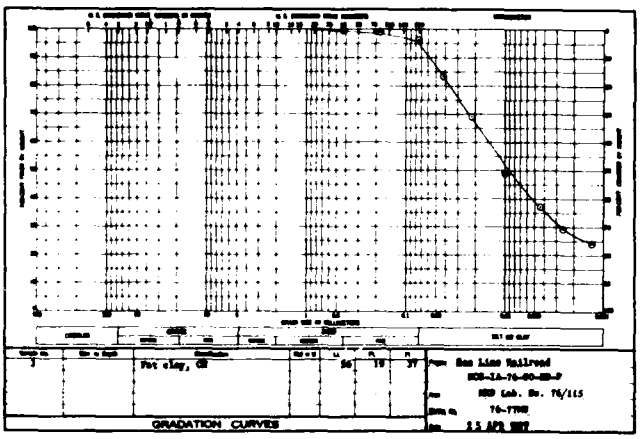
CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT FORMAT AFTER ENG FORM 2087

FIGURE 12

④

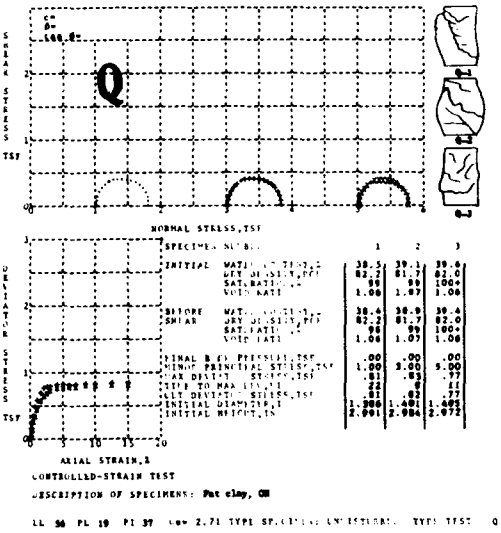
SEE NOTE PLATE B-49



GRADATION CURVES

Figure 13

⑦



NORMAL STRESS, TSF

AXIAL STRAIN, %

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Fat clay, CH

LL 56 PL 19 PI 37 Gs= 2.71 TYPE SPECIMEN UNDISTURBED TYPE TEST Q

SPECIMEN NUMBER		1	2	3
INITIAL	MOISTURE CONTENT, %	38.5	39.1	39.6
	DRY DENSITY, PCF	82.2	81.7	82.0
	SATURATION, %	99	99	100+
	VOID RATIO	1.06	1.07	1.06
BEFORE SHEAR	MOISTURE CONTENT, %	38.6	38.9	39.4
	DRY DENSITY, PCF	82.2	81.7	82.0
	SATURATION, %	99	99	100+
	VOID RATIO	1.06	1.07	1.06
FINAL B.P. PRESSURE, TSF		.00	.00	.00
MINOR PRINCIPAL STRESS, TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS, TSF		.81	.83	.77
STRAIN TO MAX DEVIATOR, %		22	8	11
ULT DEVIATOR STRESS, TSF		.81	.83	.77
INITIAL DIAMETER, in		2.866	1.481	1.485
INITIAL HEIGHT, in		2.901	2.984	2.972

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2069
Gray, soft to medium consistency. Medium strength at PL, dull shine.

PROJECT: Soo Line Railroad SOO-LA-76-00-SD-F

BORING NO: 76-77M SAMPLE NO: 3

DEPTH:

SOO LAB NO: 76/115 DATE 5 APR 77

TRIAXIAL COMPRESSION TEST REPORT

FIGURE 9

⑧

DESIGN MEMORANDUM NO. 3 GENERAL

FLOOD CONTROL – LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

SOILS TEST DATA
SOO LINE RAILROAD

BORING 76-77 M

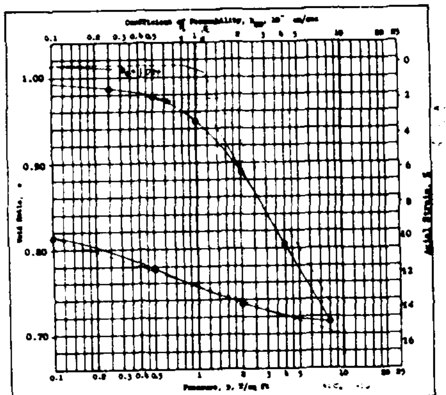
ST PAUL, MINN DISTRICT

JUNE 1983

R I - R - 5 / 7 6 8

PLATE NO. B-69

1 2

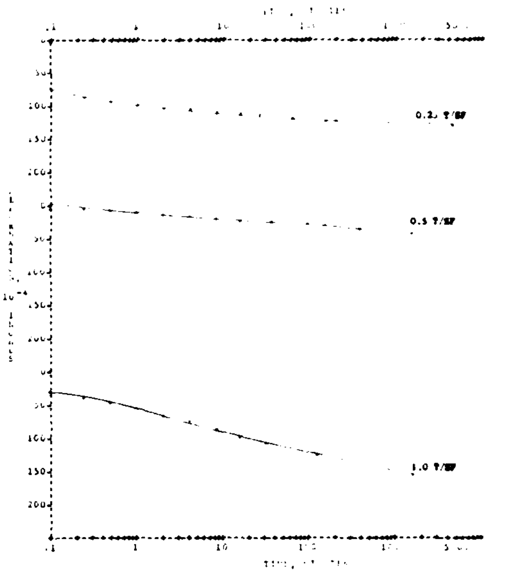


Type of Specimen		Before Test		After Test	
Diam 4.28 in.	Ht 1.00 in.	Water Content, w_o	34.8 %	w_f	30.0 %
Overburden Pressure, p_o T/sq ft		Void Ratio, e_o	1.014	e_f	0.813
Preconsol. Pressure, p_c T/sq ft		Saturation, S_o	93 %	S_f	100 %
Compression Index, C_c		Dry Density, γ_d	83.9 lb/ft³		
Classification Fat clay, CH		k_{20} at e_o = x 10 cm/sec			
LL 56	G_s 2.71	Project See Line Railroad			
PL 19	D_{10}	NCS-IA-76-80-ED-F			
Remarks		Area MRD Lab. No. 76/115			
		Boring No. 76-77NE		Sample No. 3	
		Depth 20.5 - 22.4		Date 25 APR 1977	

CONSOLIDATION TEST REPORT

Figure 9

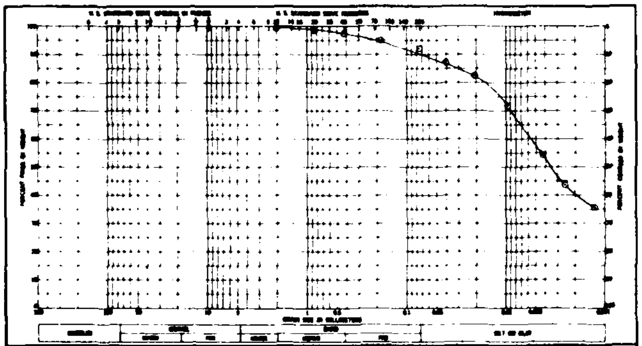
①



PROJECT: See Line Railroad NCS-IA-76-80-ED-F
MRD LABORATORY NO: 76/115
BORING NO: 76-77NE SAMPLE NO: 3 DEPTH: 20.5 - 22.4 DATE: 25 APR 1977

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088 FIG 10

②



Boring No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
B-4	20.5 - 20.4	Fat clay, CH		60	23	43

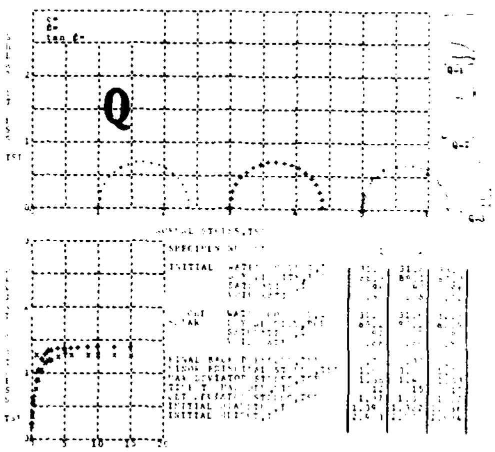
Project See Line Railroad
NCS-IA-76-80-ED-F
Area MRD Lab. No. 76/115
Boring No. 76-77NE
Date 30 MAR 1977

GRADATION CURVES

ENG FORM 2087

Figure 7

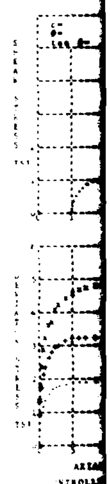
⑤

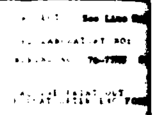


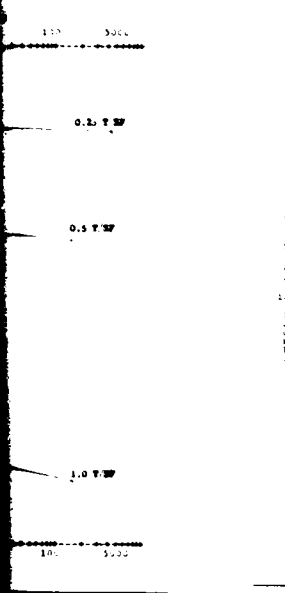
AXIAL STRAIN, %
CONTROLLED-STRAIN TEST
DESCRIPTION OF SPECIMENS: Fat clay, CH
LL 60 PL 23 PI 43
REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2089
Dark gray, medium consistency. High strength at PL, gloss shine, no shake reaction. Sample contained some large roots. Torvane - 0.65 T/SF

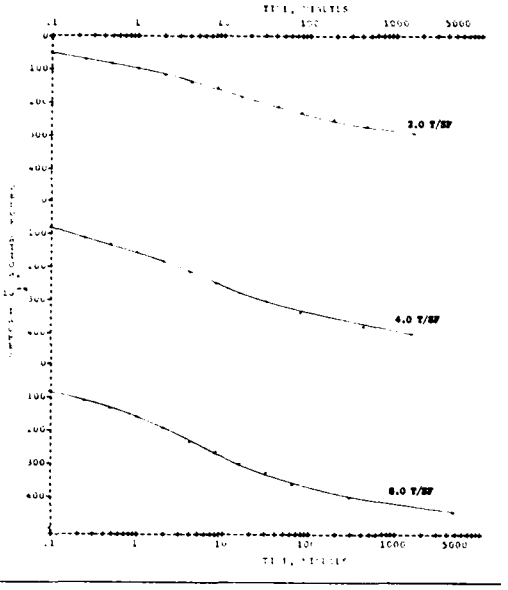
PROJECT: See Line NCS-IA-76-80-ED-F
BORING NO: 76-77NE SAMPLE NO: 4
DEPTH: 20.5 - 20.4
MRD LAB NO: 76/115 DATE: 30 MAR 1977
TRIAXIAL COMPRESSION TEST REPORT

⑥









PROJECT: Soo Line Railroad MCS-1A-76-80-SD-F

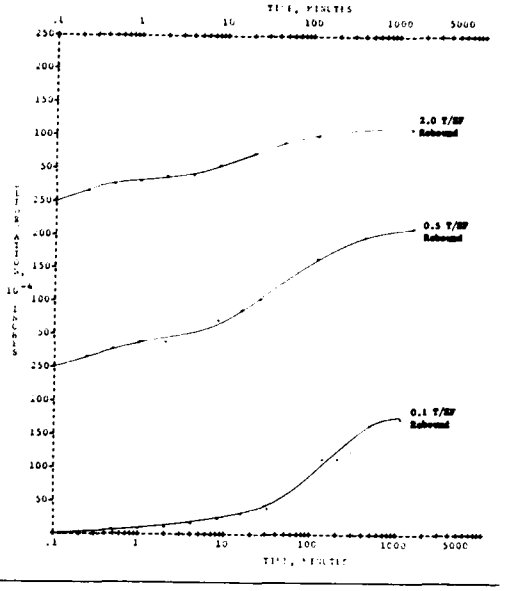
LAB LABORATORY NO: 76/115

BORING NO: 76-77MD SAMPLE NO: 3 DEPTH: 20.5 - 22.4 DATE: 25 APR 1977

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2086 FIGURE 10

③



PROJECT: Soo Line Railroad MCS-1A-76-80-SD-F

LAB LABORATORY NO: 76/115

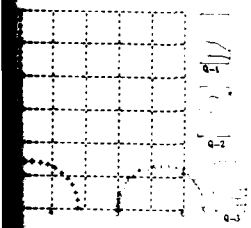
BORING NO: 76-77MD SAMPLE NO: 3 DEPTH: 20.5 - 22.4 DATE: 25 APR 1977

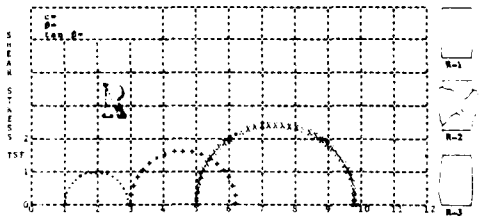
CONSOLIDATION TEST -- TIME CURVES

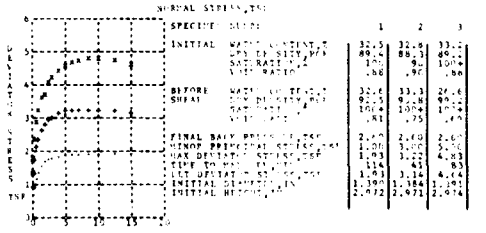
MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2086 FIGURE 12

④

SEE NOTE PLATE B-49







SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT, %	32.5	32.6	33.1
	DRY DENSITY, PCF	89.4	88.3	86.2
	SATURATION, %	100	96	100+
	VOID RATIO	.86	.90	.96
BEFORE SHEAR	WATER CONTENT, %	32.6	33.3	34.6
	DRY DENSITY, PCF	90.5	90.8	89.2
	SATURATION, %	100+	100+	100+
	VOID RATIO	.81	.75	.85
FINAL DAILY READING		2.69	2.69	2.69
MINOR PRINCIPAL STRESS, TSF		1.00	2.00	3.00
MAX. DEVIATOR STRESS, TSF		1.93	3.23	4.83
TIME TO FAILURE, MIN.		114	41	93
LIFT-OFF STRESS, TSF		1.93	3.14	4.64
INITIAL DIAL READING		1.399	1.384	1.391
INITIAL HEIGHT, IN		2.972	2.971	2.974

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMEN: Fat clay, CH

LL 66 PL 23 PI 43 USCS CLASSIFICATION: UNDISTURBED TYPE OF TEST: B

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2086

B value = 0.95

PROJECT: Soo Line MCS-1A-76-80-SD-F

BORING NO: 76-77MD SAMPLE NO: 4

DEPTH: 26.5 - 28.4

LAB NO: 76/115 DATE: 30 MAR 1977

TRIAXIAL COMPRESSION TEST REPORT

PLATE 1

PROJECT: Soo Line MCS-1A-76-80-SD-F

BORING NO: 76-77MD SAMPLE NO: 4

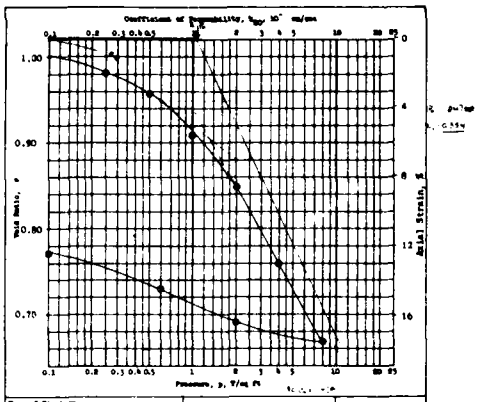
DEPTH: 26.5 - 28.4

LAB NO: 76/115 DATE: 30 MAR 1977

TRIAXIAL COMPRESSION TEST REPORT

PLATE 2

⑦



Type of Specimen	Undisturbed		Before Test		After Test
Diam 4.40 in.	Ht 1.00 in.	Water Content, w_o	34.5 %	w_f	30.0 %
Overburden Pressure, p_o T/sq ft		Void Ratio, e_o	1.022	e_f	0.773
Preconsol. Pressure, p_c T/sq ft		Saturation, S_o	91 %	S_f	100+ %
Compression Index, C_c		Dry Density, γ_d	83.0 lb/ft³		
Classification		c_v at e_o =	= 10^{-3} sq cm/sec		
LL 66	G_s 2.69	Project	Soo Line Railroad MCS-1A-76-80-SD-F		
PL 23	P_{10}	Area	MRD Lab. No. 76/115		
Remarks		Boring No. 76-77MD	Sample No. 4		
		Depth 26.5 - 28.4 ft	Date 30 MAR 1977		

CONSOLIDATION TEST REPORT

Figure 3

⑧

DESIGN MEMORANDUM NO. 3 GENERAL

FLOOD CONTROL – LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

SOILS TEST DATA
SOO LINE RAILROAD

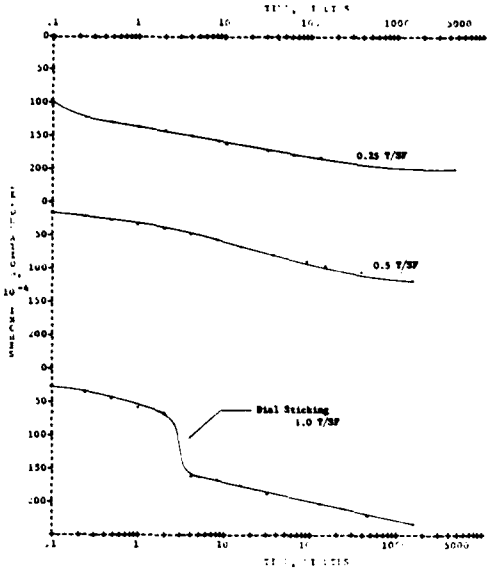
BORING 76-77M

ST PAUL, MINN DISTRICT

JUNE 1983

RI - R - 5/769

PLATE NO. B-70



PROJECT: Soo Line Railroad NCS-1A-76-90-ED-F

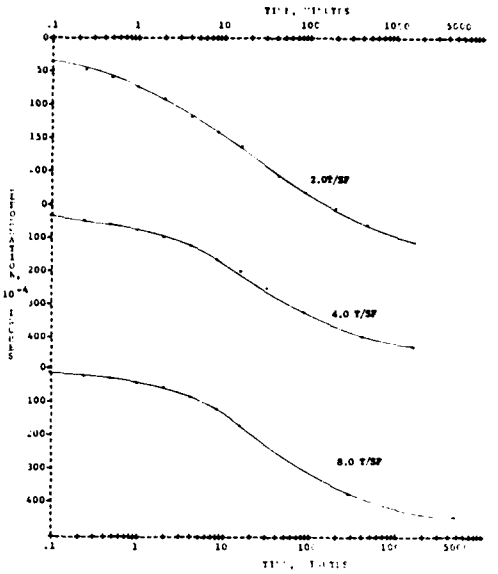
NRD LABORATORY NO: 76/115

BORING NO: 76-7780 SAMPLE NO: 4 DEPTH: 26.5 - 28.4 DATE: 30 MAR 1977

CONSOLIDATION TEST REPORT

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088 FIGURE 4

①



PROJECT: Soo Line Railroad NCS-1A-76-90-ED-F

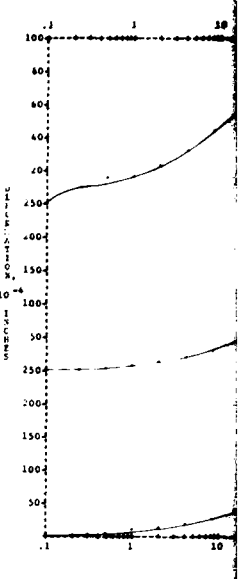
NRD LABORATORY NO: 76/115

BORING NO: 76-7780 SAMPLE NO: 4 DEPTH: 26.5 - 28.4 DATE: 30 MAR 1977

CONSOLIDATION TEST REPORT

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088 FIGURE 5

②



PROJECT: Soo Line Railroad NCS-1A-76-90-ED-F

NRD LABORATORY NO: 76/115

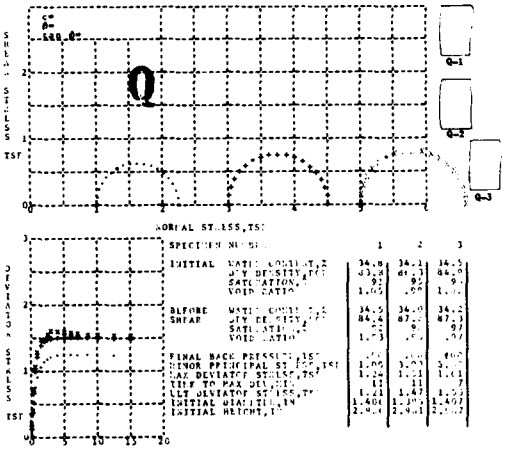
BORING NO: 76-7780 SAMPLE NO: 4

CONSOLIDATION TEST REPORT

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

③

* SEE NOTE



		1	2	3
INITIAL	WATER CONTENT, %	34.9	34.1	34.5
	DRY DENSITY, PCF	83.1	84.0	84.0
	SATURATION, %	93	96	96
	VOID RATIO	1.02	.99	1.00
BEFORE SHEAR	WATER CONTENT, %	34.5	34.0	34.2
	DRY DENSITY, PCF	84.4	87.2	87.3
	SATURATION, %	93	98	97
	VOID RATIO	1.03	.93	.97
FINAL BACK PRESSURE, TSF		4.0	4.0	4.0
MINOR PRINCIPAL STRESS, TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS, TSF		1.24	1.21	1.21
TIME TO MAX DEVIATOR, MIN		11	11	11
LAST DEVIATOR STRESS, TSF		1.21	1.17	1.17
INITIAL DIAMETER, IN		1.401	1.397	1.402
INITIAL HEIGHT, IN		2.904	2.901	2.900

AXIAL STRAIN, %

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Fat clay, CH

LL 85 PL 36 PI 99 Gs= 2.75 TYPE: SELECT SOURCE: ... TYPE TEST: ...

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089
Gray, medium consistency, high strength at PL, glossy shine, no shake reaction, slight odor.

PROJECT: Soo Line Railroad
NCS-1A-76-90-ED-F

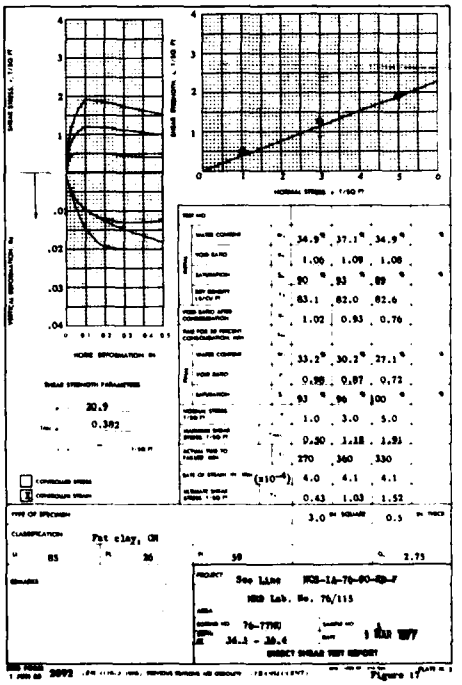
BORING NO: 76-7780 SAMPLE NO: 5

DEPTH: 34.5 - 36.4

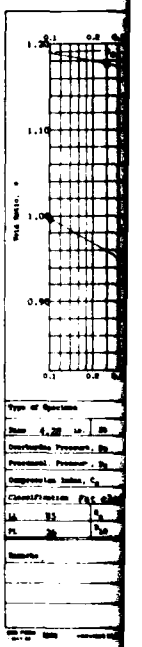
NRD LAB NO: 76/115 DATE: 9 MAR 1977

TRIAXIAL COMPRESSION TEST REPORT

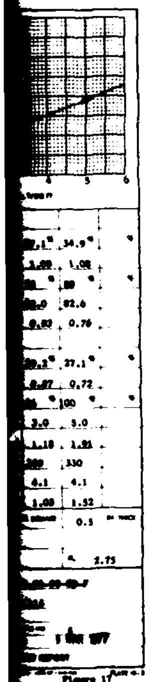
⑤



⑥



U. S. ARMY



PROJECT: Soo Line Railroad WCS-IA-76-90-EB-F

NRD LABORATORY NO: 76/115

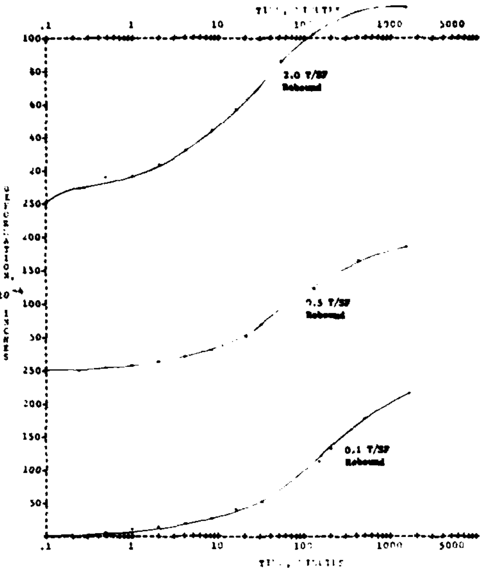
BORING NO: 76-77MU SAMPLE NO: 4 DEPTH: 26.5 - 28.4 DATE: 10 MAR 1977

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

FIGURE 6

③



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
5	34.5 - 36.4	Fat clay, CH		85	26	59

Project: Soo Line Railroad WCS-IA-76-90-EB-F

NRD Lab. No. 76/115

Boring No. 76-77MU

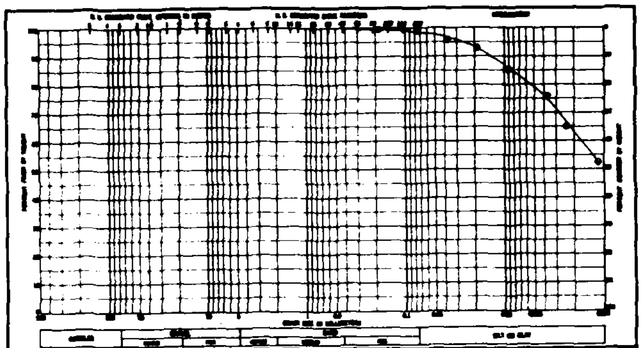
Date 9 MAR 1977

GRADATION CURVES

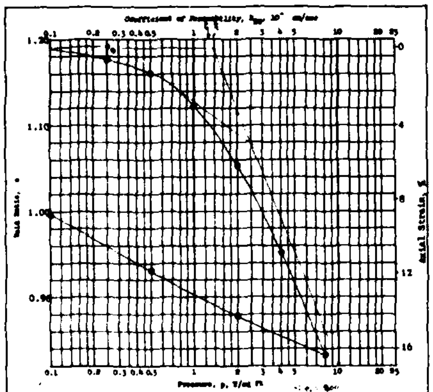
ENG FORM 2087

Figure 22

④



* SEE NOTE PLATE B-49



Type of Specimen		Before Test			After Test
Diam 4.20 in.	Ht 1.00 in.	Water Content, w_o	39.8 %	w_f	35.1 %
Overburden Pressure, p_o T/sq ft		Void Ratio, e_o	1.190	e_f	0.995
Preconsol. Pressure, p_c T/sq ft		Saturation, S_o	92 %	S_f	100 %
Compression Index, C_c		Dry Density, γ_d	78.3 lb/ft³		
Classification Fat clay, CH		k_{20} at e_o = x 10⁻ cm/sec			
LL 85	G_s 2.75				
PL 26	D_{10}				
Remarks					

Project: Soo Line Railroad WCS-IA-76-90-EB-F

NRD Lab. No. 76/115

Area

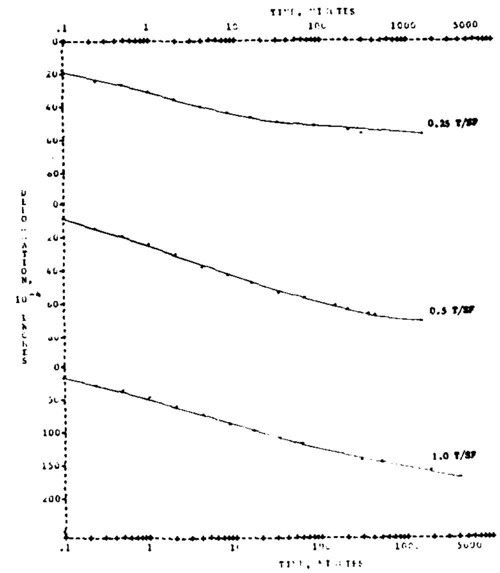
Boring No. 76-77MU Sample No. 5

Depth 34.5 - 36.4 Date 9 MAR 1977

CONSOLIDATION TEST REPORT

Figure 18

⑦



PROJECT: Soo Line Railroad WCS-IA-76-90-EB-F

NRD LABORATORY NO: 76/115

BORING NO: 76-77MU SAMPLE NO: 5 DEPTH: 34.5 - 36.4 DATE: 9 MAR 1977

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

FIGURE 19

⑧

DESIGN MEMORANDUM NO. 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

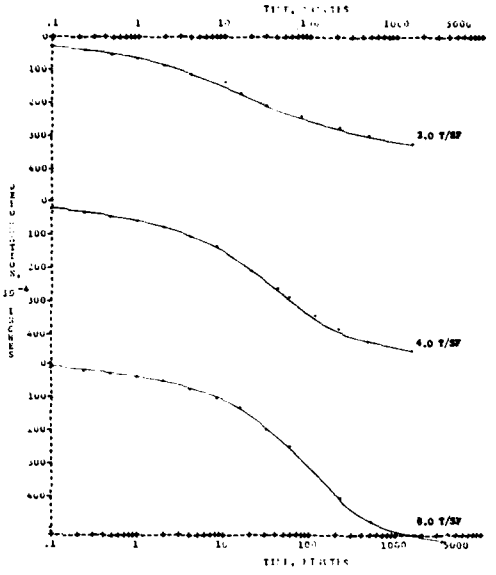
SOILS TEST DATA
SOO LINE RAILROAD
BORING 76-77M

ST PAUL, MINN DISTRICT

JUNE 1983

RI-R-S/770

PLATE NO. B-7



PROJECT: Soo Line Railroad MCS-1A-76-80-ED-F

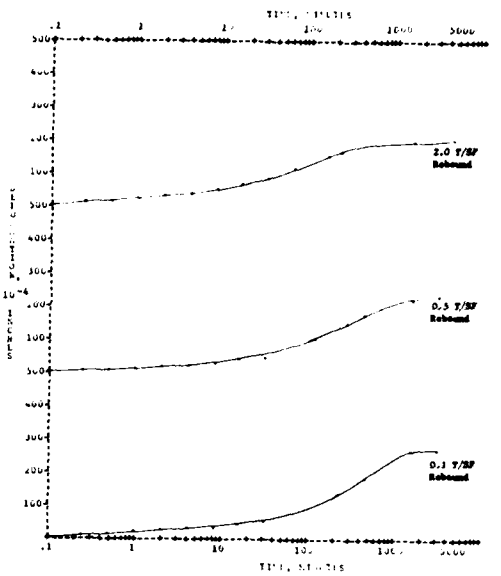
FKD LABORATORY NO: 76/115

BORING NO: 76-7708 SAMPLE NO: 5 DEPTH: 34.5 - 36.4 DATE: 8 MAR 1977

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2087 FIGURE 20

①



PROJECT: Soo Line Railroad MCS-1A-76-80-ED-F

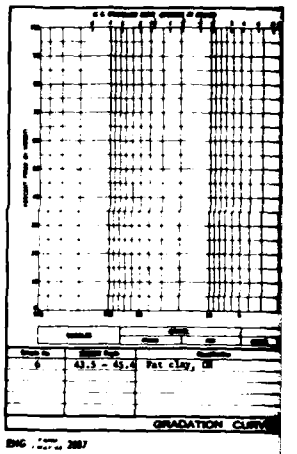
FKD LABORATORY NO: 76/115

BORING NO: 76-7708 SAMPLE NO: 5 DEPTH: 34.5 - 36.4 DATE: 8 MAR 1977

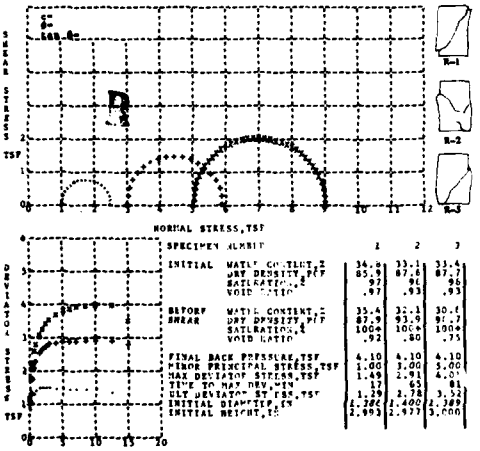
CONSOLIDATED TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2087 FIGURE 21

②



ENG FORM 2087



SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT, %	34.6	33.1	33.4
	DRY DENSITY, PCF	85.9	87.6	87.7
	SATURATION, %	.97	.96	.96
	VOID RATIO	.97	.93	.93
BEFORE SHEAR	WATER CONTENT, %	35.4	32.1	30.6
	DRY DENSITY, PCF	87.9	93.5	97.2
	SATURATION, %	100+	100+	100+
	VOID RATIO	.92	.80	.75
FINAL BACK PRESSURE, TSF		4.10	4.10	4.10
MINOR PRINCIPAL STRESS, TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS, TSF		1.49	2.91	4.01
TIME TO MAX DEV, MIN		17	65	81
ULT DEVIATOR STRESS, TSF		1.28	2.78	3.52
INITIAL DIAMETER, IN		1.382	1.402	1.389
INITIAL HEIGHT, IN		2.993	2.977	3.000

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Fat clay, CH

LL 64 PL 23 PI 41 Gs= 2.71 TYPE SPECIMEN: UNDISTURBED TYPE TEST S

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089
S value = 1.00

PROJECT: Soo Line Railroad
MCS-1A-76-80-ED-F

BORING NO: 76-7708 SAMPLE NO: 6

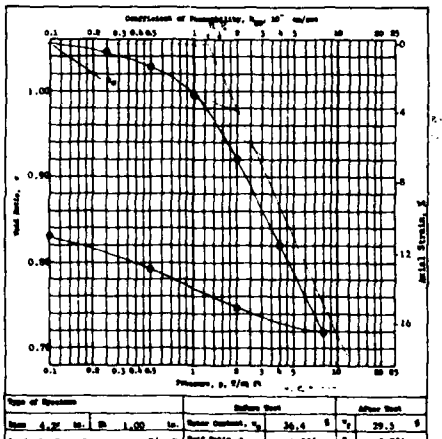
DEPTH: 43.5 - 45.4

FKD LAB NO: 76/115 DATE 30 MAR 1977

TRIAXIAL COMPRESSION TEST REPORT

FIGURE 9

⑤

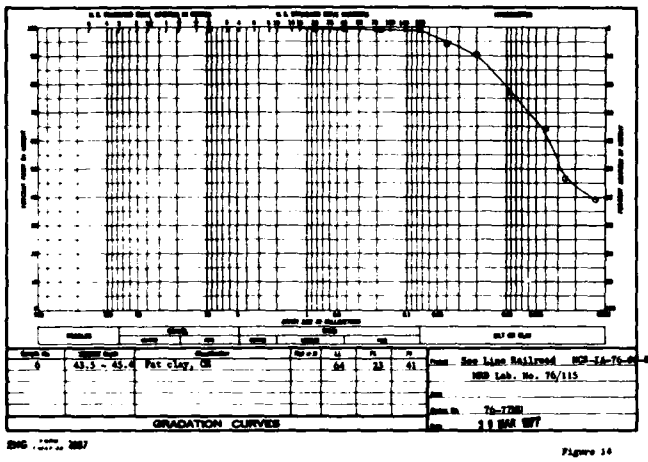


Type of Specimen		Before Test		After Test	
Diam 4.2" in.	Ht 1.00 in.	Water Content, w_o	36.4 %	w_f	29.3 %
Consolidation Pressure, p_c T/sq ft		Void Ratio, e_o	1.056	e_f	0.831
Permeant Pressure, p_p T/sq ft		Saturation, S_o	93 %	S_f	96 %
Hydraulic Gradient, i_o		Dry Density, γ_d	82.2 lb/ft³		
Classification		k_{20} at e_o =	x 10⁻⁷ cm/sec		
LL 64 PL 23	G_s 2.71	Project Soo Line Railroad			
PI 41	D_{10}	MCS-1A-76-80-ED-F			
Remarks		Lab No. 76/115			
		Boring No. 76-7708	Sample No. 6		
		Depth 43.5 - 45.4	Date 30 MAR 1977		

CONSOLIDATION TEST REPORT

Figure 10

⑥



Sample No.	Depth	Classification	LL	PL	PI
6	43.5 - 45.4	Fat clay, CH	64	23	41

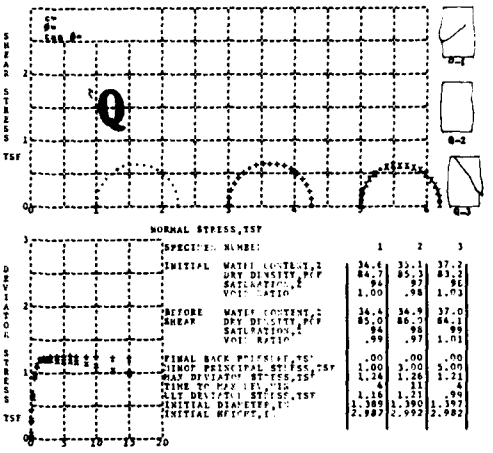
Name: Soo Line Railroad MCR-1A-76-80-ED-F
MRD Lab. No. 76/115
Date Rec'd: 76-77MD
Date: 30 MAR 1977

GRADATION CURVES

ENG ... 2087

Figure 14

③



SPECIMEN NUMBER:		1	2	3
INITIAL	WATER CONTENT, %	34.6	33.1	37.2
	DRY DENSITY, PCF	84.7	85.3	83.2
	SATURATION, %	96	97	96
	VOID RATIO	1.00	.98	1.03
BEFORE SHEAR	WATER CONTENT, %	34.4	34.9	37.0
	DRY DENSITY, PCF	85.0	86.0	84.1
	SATURATION, %	96	98	99
	VOID RATIO	.99	.97	1.01
FINAL BACK PRESSURE, TSF		.00	.00	.00
MINOR PRINCIPAL STRESS, TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS, TSF		1.24	1.26	1.21
TIME TO FAILURE, MIN		4	11	4
ULT DEVIATOR STRESS, TSF		1.16	1.21	.99
INITIAL DIAMETER, IN		1.389	1.390	1.397
INITIAL HEIGHT, IN		2.987	2.992	2.982

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Fat clay, CH

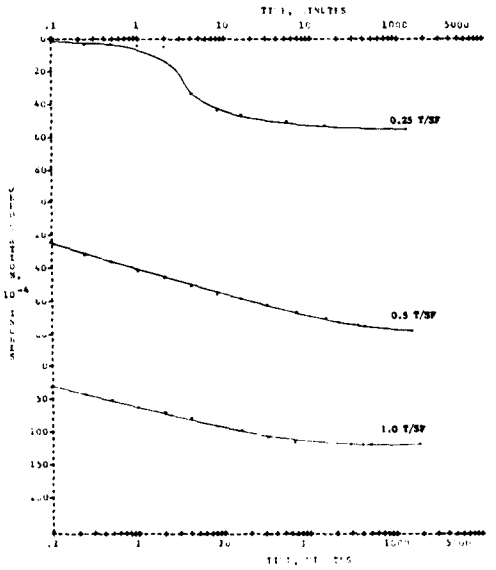
LL 64 PL 23 PI 41 Gs= 2.71 TYPE SPECIMENS: UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2087
Gray, medium strength at PL, gloss shine, no shake reaction.

PROJECT: Soo Line Railroad MCR-1A-76-80-ED-F
BORING NO: 76-77MD SAMPLE NO: 6
DEPTH: 43.5 - 45.4
MRD LAB NO: 76/115 DATE 30 MAR 1977
TRIAXIAL COMPRESSION TEST REPORT
FIGURE 9

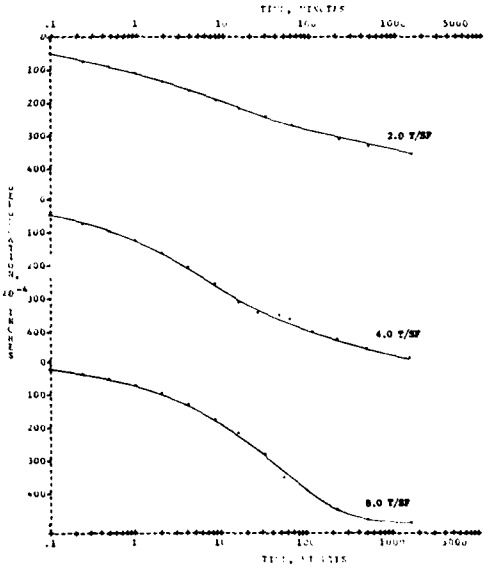
④

*SEE NOTE PLATE B-49



PROJECT: Soo Line Railroad MCR-1A-76-80-ED-F
MRD LABORATORY NO: 76/115
BORING NO: 76-77MD SAMPLE NO: 6 DEPTH: 43.5 - 45.4 DATE: 30 MAR 1977
CONSOLIDATION TEST -- TIME CURVES
MACHINE PRINT OUT FORMAT AFTER ENG FORM 2087 FIGURE 11

⑦

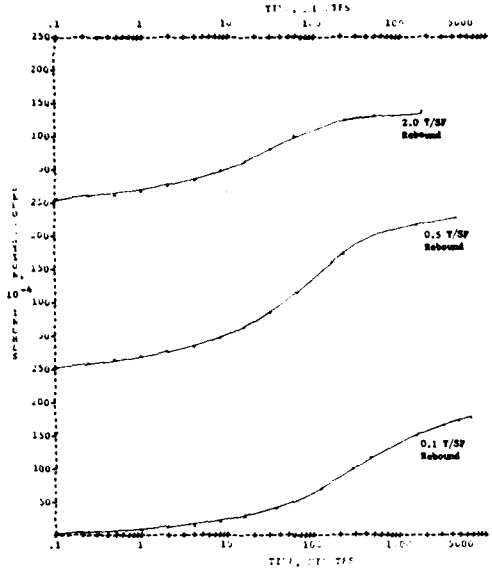


PROJECT: Soo Line Railroad MCR-1A-76-80-ED-F
MRD LABORATORY NO: 76/115
BORING NO: 76-77MD SAMPLE NO: 6 DEPTH: 43.5 - 45.4 DATE: 30 MAR 1977
CONSOLIDATION TEST -- TIME CURVES
MACHINE PRINT OUT FORMAT AFTER ENG FORM 2087 FIGURE 12

⑧

DESIGN MEMORANDUM NO. 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
SOILS TEST DATA
SOO LINE RAILROAD
BORING 76-77 M
ST PAUL, MINN DISTRICT
JUNE 1983

R1-R-B/771 PLATE NO.B-72



PROJECT: Soo Line Railroad MCS-1A-76-90-SD-F

NRD LABORATORY NO: 76/115

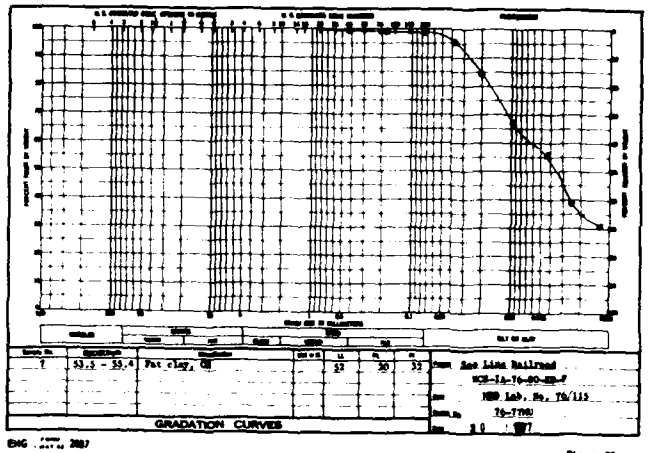
BORING NO: 76-77MU SAMPLE NO: 6 DEPTH: 43.5 - 45.4 DATE: 30 MAR 77

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2...

FIGURE 16

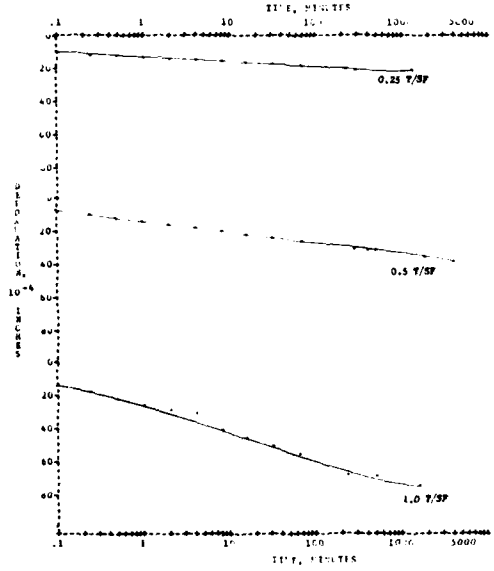
①



ENG FORM 2087

Figure 20

②



PROJECT: Soo Line Railroad MCS-1A-76-90-SD-F

NRD LABORATORY NO: 76/115

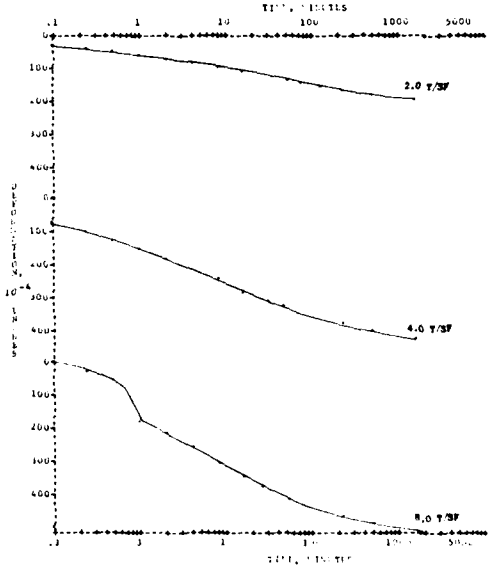
BORING NO: 76-77MU SAMPLE NO: 7 DEPTH: 53.5 - 55.4 DATE: 30 MAR 77

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

FIGURE 17

⑤



PROJECT: Soo Line Railroad MCS-1A-76-90-SD-F

NRD LABORATORY NO: 76/115

BORING NO: 76-77MU SAMPLE NO: 7 DEPTH: 53.5 - 55.4 DATE: 30 MAR 77

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

FIGURE 18

⑤

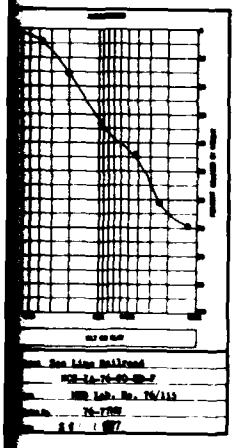
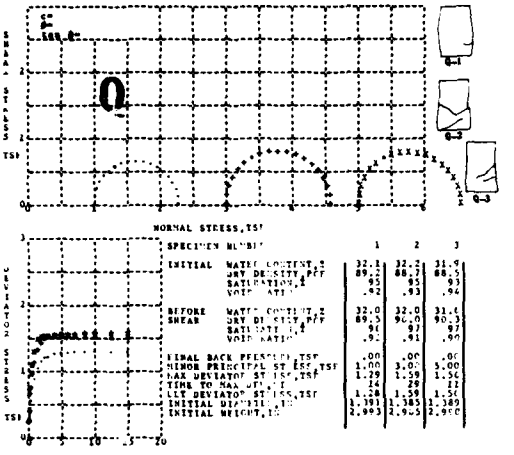


Figure 20



SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT, %	32.1	32.2	31.9
	DRY DENSITY, PCF	89.2	88.7	88.5
	SATURATION, %	95	95	93
	VOID RATIO	.92	.93	.94
BEFORE SHEAR	WATER CONTENT, %	32.0	32.0	31.6
	DRY DENSITY, PCF	89.5	90.0	90.3
	SATURATION, %	91	97	97
	VOID RATIO	.91	.91	.90
FINAL BACK PRESSURE, TSF		.00	.00	.00
MINOR PRINCIPAL STRESS, TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS, TSF		1.29	1.59	1.56
TIME TO MAX DEVIATOR		14	29	12
ULT DEVIATOR STRESS, TSF		1.28	1.59	1.56
INITIAL DIAMETER, IN		1.391	1.385	1.389
INITIAL WEIGHT, LB		2.093	2.905	2.900

AXIAL STRAIN, %

CONTROLLED-STRAIN TEST

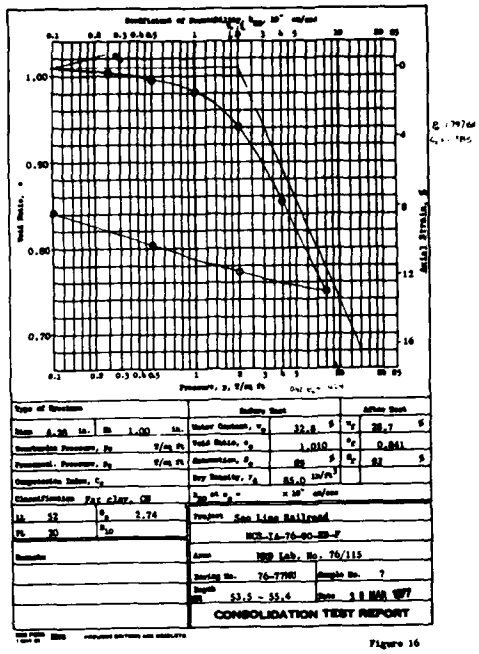
DESCRIPTION OF SPECIMENS:

LL 32 PL 20 PI 12 Gs= 2.75 TYPE SPECIMEN: UNDISTURBED TYPE TEST Q

REMARKS: ACHIEVE PRINT OUT FORMAT AFTER ENG FORM 2089
Gray, medium consistency. Medium strength at PL, gloss shine, slight shake reaction.

PROJECT: Soo Line Railroad MCR-1A-76-90-MN-F
BORING NO: 76-77M SAMPLE NO: 7
DEPTH: 53.5 - 55.4
MRD LAB NO: 76/115 DATE: 18 MAR 1977
TRIAXIAL COMPRESSION TEST REPORT

③



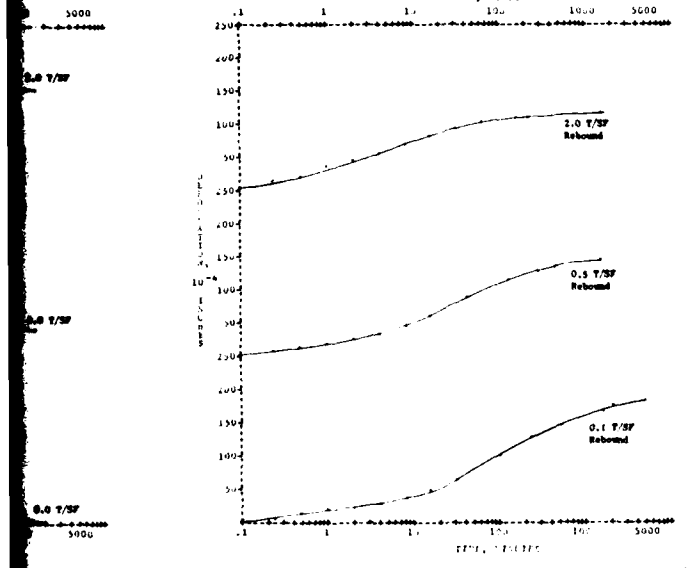
Type of Specimen	Before Test	After Test
Diam 2.38 in. H 1.00 in.	Water Content, w_o 32.8 %	w_f 28.7 %
Consolidation Pressure, P_c T/sq ft	Void Ratio, e_o 1.010	e_f 0.841
Permeant. Pressure, P_p T/sq ft	Saturation, S_o 89 %	S_f 92 %
Compression Index, C_c	Dry Density, γ_d 85.0 lb/ft³	
Classification Fat clay, CH	k_{20} at e_o = x 10⁻⁶ cm/sec	
LL 52	G_s 2.74	Project Soo Line Railroad
PL 20	S_o	MCR-1A-76-90-MN-F
Remarks		Area MRD Lab. No. 76/115
		Boring No. 76-77M Sample No. 7
		Depth 53.5 - 55.4 Date 18 MAR 1977

CONSOLIDATION TEST REPORT

Figure 16

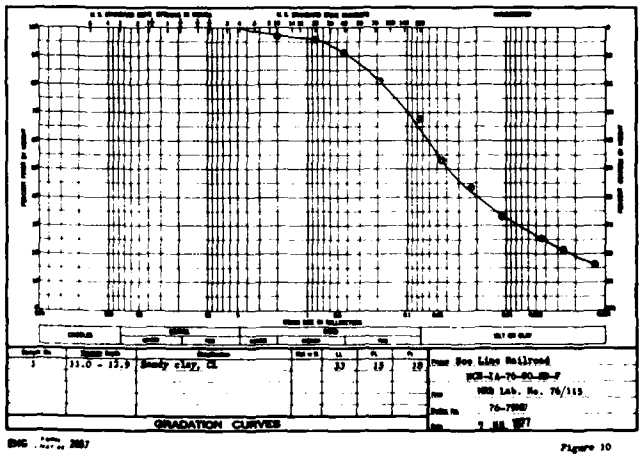
④

*SEE NOTE PLATE B-49



PROJECT: Soo Line Railroad MCR-1A-76-90-MN-F
MRD LABORATORY NO: 76/115
BORING NO: 76-77M SAMPLE NO: 7 DEPTH: 53.5 - 55.4 DATE: 18 MAR 1977
CONSOLIDATION TEST -- TIME CURVES
MACHINE PRINT OUT FORMAT AFTER ENG FORM 2089

⑦



Sample No.	Depth	Classification	LL	PL	PI
7	53.0 - 55.9	Sandy clay, CL	33	19	19

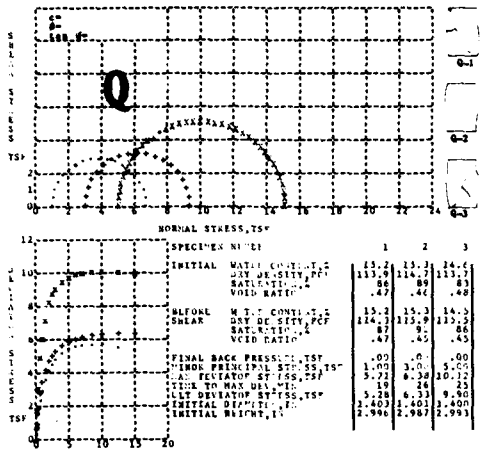
Project Soo Line Railroad MCR-1A-76-90-MN-F
Area MRD Lab. No. 76/115
Boring No. 76-77M
Date 18 MAR 1977

Figure 10

⑧

DESIGN MEMORANDUM NO. 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
SOILS TEST DATA
SOO LINE RAILROAD
BORINGS 76-77M AND 76-79M
ST PAUL, MINN DISTRICT
JUNE 1983

RI-R-5/772 PLATE NO. B-73



SPECIMEN NUMBER		1	2	3
INITIAL	MOIST. CONTENT,%	15.2	15.3	14.6
	DRY DENSITY,PCF	113.6	114.7	113.7
	SATURATION,%	86	89	83
	VOID RATIO	.47	.46	.48
BEFORE SHEAR	MOIST. CONTENT,%	15.3	15.3	14.5
	DRY DENSITY,PCF	114.3	113.9	115.3
	SATURATION,%	87	91	86
	VOID RATIO	.47	.45	.45
FINAL BACK PRESSURE,TSF		.00	.00	.00
MINOR PRINCIPAL STRESS,TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS,TSF		5.72	8.38	10.12
TIME TO MAX DEV,MIN		19	26	25
ULT DEVIATOR STRESS,TSF		5.28	6.33	9.80
INITIAL DIMENSIONS		1.403	1.401	1.400
INITIAL WEIGHT,LB		2.996	2.987	2.993

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

LL 33 PL 15 PI 18 Gs= 2.69 TYPE SPECIMEN : UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2089

Gray, brittle structure, stiff consistency, medium strength at PL, dull shine, medium shake reaction.

PROJECT: Soo Line Railroad
HCR-1A-76-80-ED-F

BORING NO: 76-79MW SAMPLE NO: 1

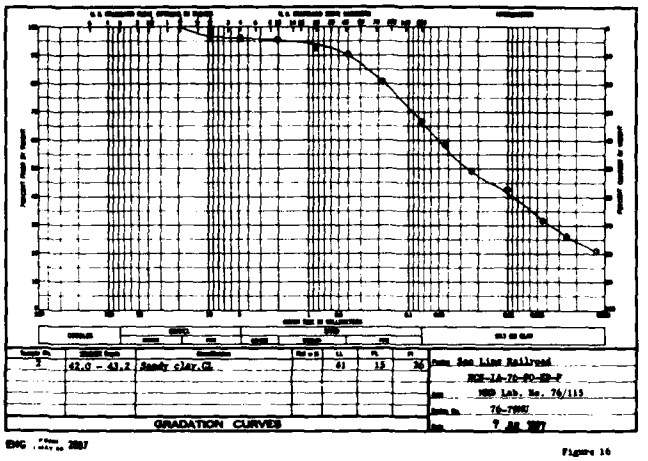
DEPTH: 11.0 - 12.9

MRD LAB NO: 76/115 DATE: 7 JUL 1977

TRIAXIAL COMPRESSION TEST REPORT

FIGURE 9

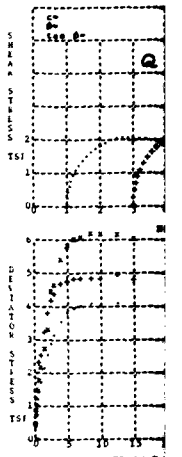
①



ENG Form 2087

Figure 10

②



AXIAL STRAIN,%

CONTROLLED-STRAIN T

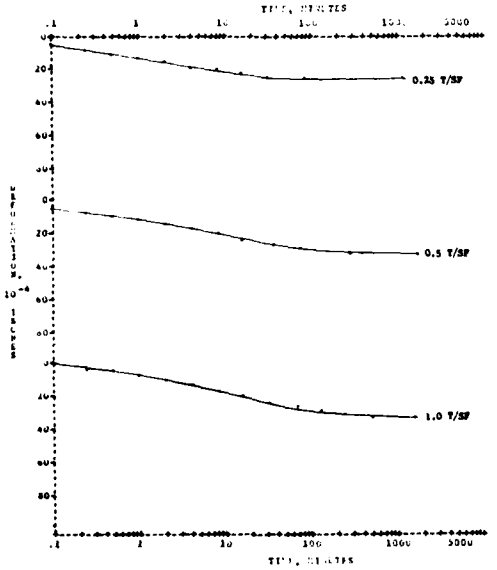
DESCRIPTION OF SPE

LL 41 PL 15 PI

REMARKS: MACHINE
FORMAT AFTER ENG

Gray, sodium to stiff
medium strength at
slow shake reaction,
tains sand and gravel
in diameter.

* SEE NOTE PLATE



PROJECT: Soo Line Railroad HCR-1A-76-80-ED-F

MRD LABORATORY NO: 76/115

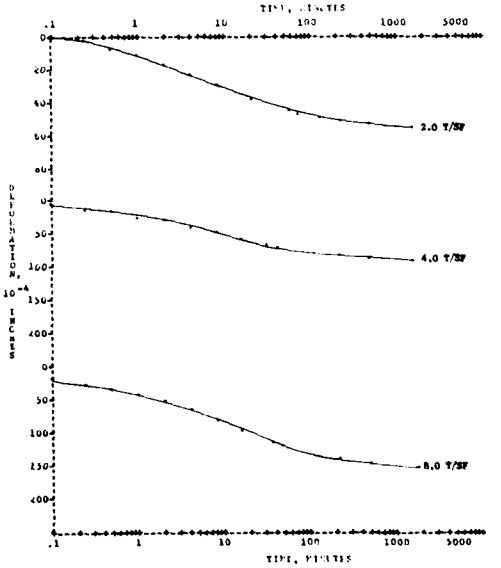
BORING NO: 76-79MW SAMPLE NO: 2 DEPTH: 42.0 - 43.2 DATE: 7 JUL 1977

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2046

FIGURE 13

⑤



PROJECT: Soo Line Railroad HCR-1A-76-80-ED-F

MRD LABORATORY NO: 76/115

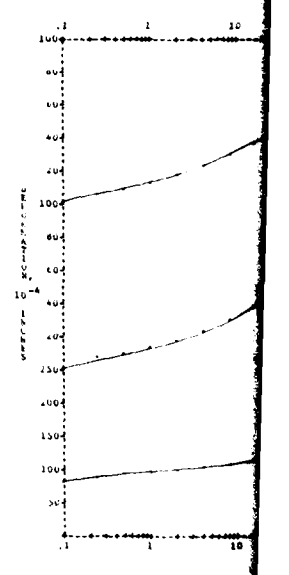
BORING NO: 76-79MW SAMPLE NO: 2 DEPTH: 42.0 - 43.2 DATE: 7 JUL 1977

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2046

FIGURE 14

⑥



PROJECT: Soo Line Railroad HCR-

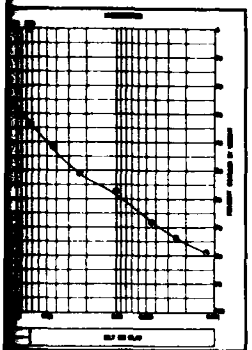
MRD LABORATORY NO: 76/115

BORING NO: 76-79MW SAMPLE NO: 3

CONSOLIDA

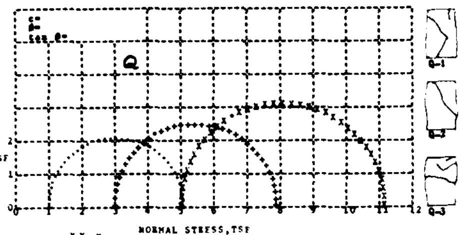
MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2046

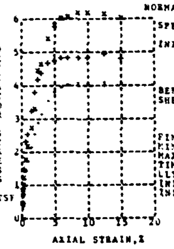
U. S. ARMY



Project	Soo Line Railroad
	NCS-IA-76-80-ED-F
Area	NBD Lab. No. 76/115
Boring No.	76-79M
	7 JUL 1977

Figure 14





SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT,%	19.1	18.5	17.8
	DRY DENSITY,PCF	110.0	110.8	111.4
	SATURATION,%	95	93	91
	VOID RATIO	.55	.54	.54
BEFORE SHEAR	WATER CONTENT,%	19.0	18.4	17.7
	DRY DENSITY,PCF	112.2	119.0	114.8
	SATURATION,%	99	100+	99
	VOID RATIO	.52	.44	.49
FINAL BACK PRESSURE,TSF		.00	.00	.00
MINOR PRINCIPAL STRESS,TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS,TSF		4.09	4.90	6.16
TIME TO MAX DEV.,MIN		20	25	18
ULT DEVIATOR STRESS,TSF		4.03	4.70	6.02
INITIAL DIAMETER,IN		1.390	1.394	1.399
INITIAL HEIGHT,IN		2.992	2.965	2.965

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

LL 41 PL 15 PI 26 Gs= 2.74 TYPE SPECIMEN: UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2089

Gray, medium to stiff consistency, medium strength at PL, dull shine, slow shake reaction. Sample contains sand and gravel up to 1-inch in diameter.

PROJECT: Soo Line Railroad NCS-IA-76-80-ED-F

BORING NO: 76-79 SAMPLE NO: 2

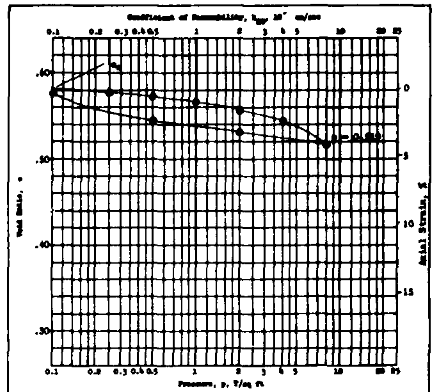
DEPTH: 42.0 - 43.2

NED LAB NO: 76/115 DATE 7 JUL 1977

TRIAXIAL COMPRESSION TEST REPORT

FIGURE 11

③

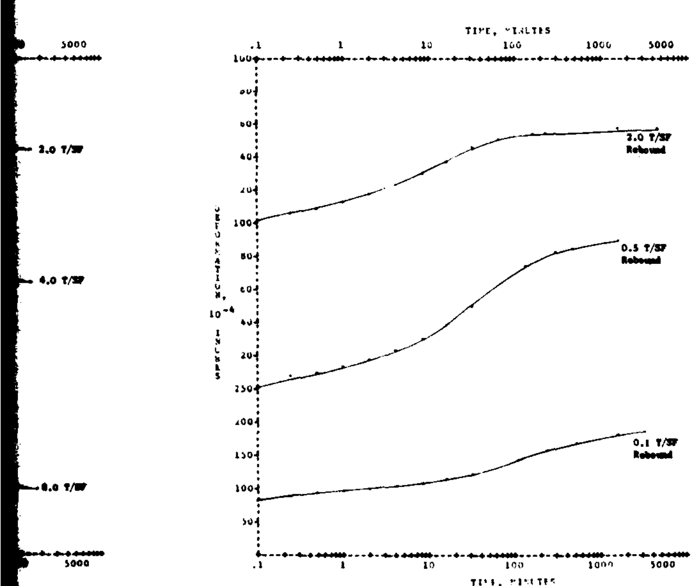


Type of Specimen		Before Test		After Test	
Diam 4.28 in.	Ht 1.00 in.	Water Content, w_o	18.9 %	w_f	19.1 %
Overburden Pressure, p_o T/sq ft		Void Ratio, e_o	0.582	e_f	0.577
Preconsol. Pressure, p_c T/sq ft		Saturation, S_o	89 %	S_f	91 %
Compression Index, C_c		Dry Density, γ_d	108.0 lb/ft³		
Classification Sandy clay, CL		k_{20} at e_o = x 10⁻ cm/sec			
LL 41	G_s 2.74	Project Soo Line Railroad			
PL 15	D_{10}	NCS-IA-76-80-ED-F			
Remarks		Area NED Lab. No. 76/115			
		Boring No. 76-79		Sample No. 2	
		Depth 42.0 - 43.2		Date 7 JUL 1977	
		CONSOLIDATION TEST REPORT			

Figure 12

④

* SEE NOTE PLATE B-49



7 JUL 1977

FIGURE 14

PROJECT: Soo Line Railroad NCS-IA-76-80-ED-F

NED LABORATORY NO: 76/115

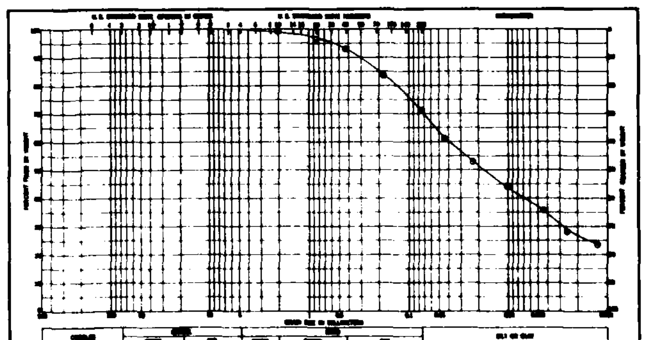
BORING NO: 76-79M SAMPLE NO: 2 DEPTH: 42.0 - 43.2 DATE: 7 JUL 1977

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT FORMAT AFTER ENG FORM 2090

FIGURE 15

⑦



Sample No.	Elev or Depth	Classification	Nat w%	LL	PL	PI
2	42.0 - 54.4	Sandy clay, CL		41	14	27

Project	Soo Line Railroad
	NED Lab. No. 76/115
Area	NCS-IA-76-80-ED-F
Boring No.	76-79M
Date	7 JUL 1977

GRADATION CURVES

ENG FORM 2087

Figure 11

⑧

DESIGN MEMORANDUM NO. 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

SOILS TEST DATA
SOO LINE RAILROAD

BORING 76-79 M

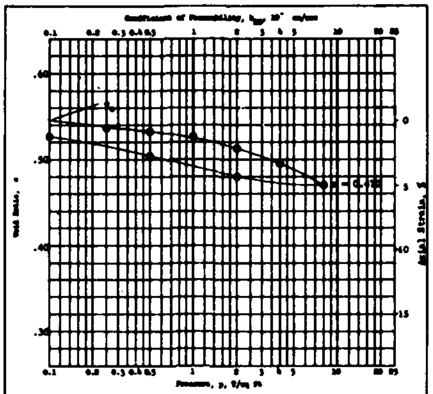
ST PAUL, MINN DISTRICT

JUNE 1983

RI-R-8/773

PLATE NO B-74

1 2



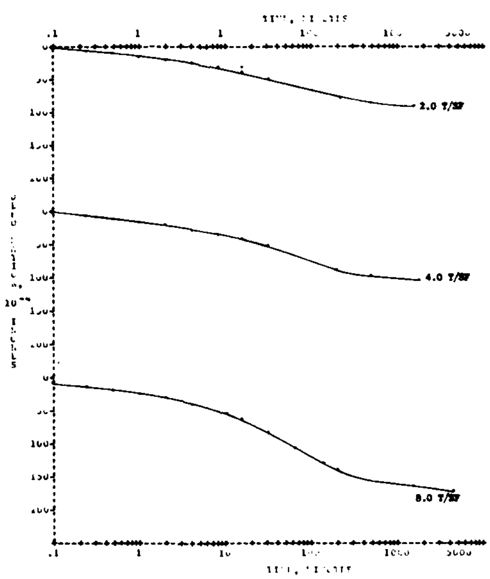
Type of Specimen		Before Test		After Test	
Diam 4.20 in.	Ht 1.00 in.	Water Content, w_o	17.6 %	w_f	18.1 %
Overburden Pressure, p_o T/sq ft		Void Ratio, e_o	0.547	e_f	0.527
Preconsol. Pressure, p_c T/sq ft		Saturation, S_o	88 %	S_f	94 %
Compression Index, C_c		Dry Density, γ_d	110.5 lb/ft^3		
Classification Sandy clay, CL		[illegible] = × 10$^-$ cm/sec			
LL 41	G_s 2.74	Project See Line Railroad			
PL 14	D_{10}	NCS-IA-76-80-ED-F			
Remarks Dark grey, medium con-		Area NRD Lab. No. 76/115			
sistency, insensitive, gloss		Boring No. 76-79[illegible]		Sample No. 3	
shine, no shake reaction.		Depth, ft 53.0 - 54.4		Date 7 JUL 1977	
Sample contains sand and gravel up		CONSOLIDATION TEST REPORT			

[illegible] to 1/2" [illegible]

Figure 17

①

* SEE NOTE PLATE B-48



PROJECT: See Line Railroad NCS-IA-76-80-ED-F

[illegible]D LABORATORY NO: 76/115

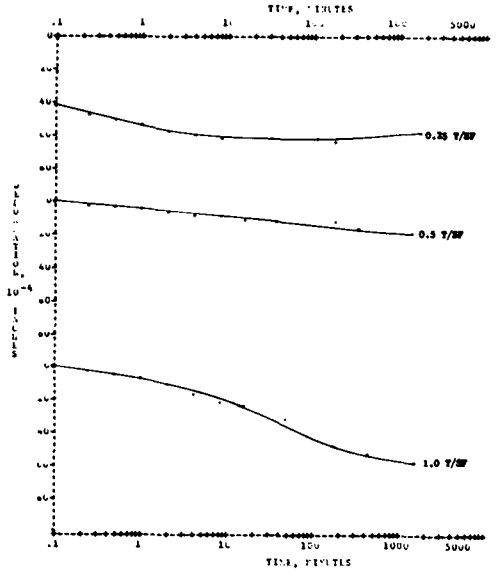
BORING NO: 76-79[illegible] SAMPLE NO: 3 DEPTH: 53.0 - 54.4 DATE: 7 JUL 1977

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM [illegible]

FIGURE 19

③



PROJECT: Soo Line Railroad MOB-IA-76-80-SB-F

CRD LABORATORY NO: 76/115

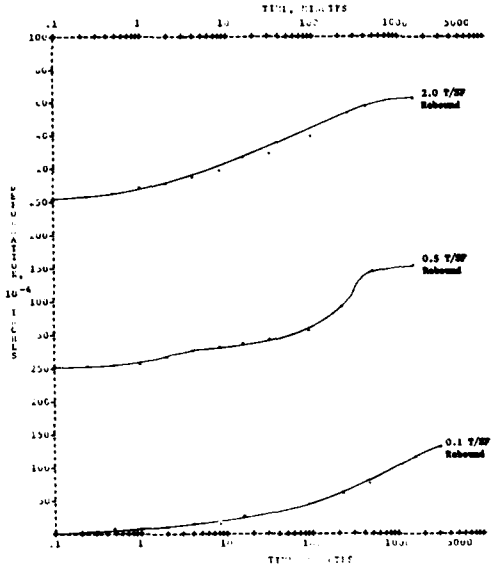
BORING NO: 76-79M SAMPLE NO: 3 DEPTH: 53.0 - 54.4 DATE: 7 JUL 1977

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER EXCEPTION: 2.0 FIGURE 18

②

*SEE NOTE PLATE B-48



PROJECT: Soo Line Railroad MOB-IA-76-80-SB-F

CRD LABORATORY NO: 76/115

BORING NO: 76-79M SAMPLE NO: 3 DEPTH: 53.0 - 54.4 DATE: 7 JUL 1977

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER EXCEPTION: 2.0 FIGURE 20

④

DESIGN MEMORANDUM NO. 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
SOILS TEST DATA
SOO LINE RAILROAD
BORING 76-79M
ST PAUL, MINN DISTRICT
JUNE 1983

RI-R-S/774 PLATE NO B-75

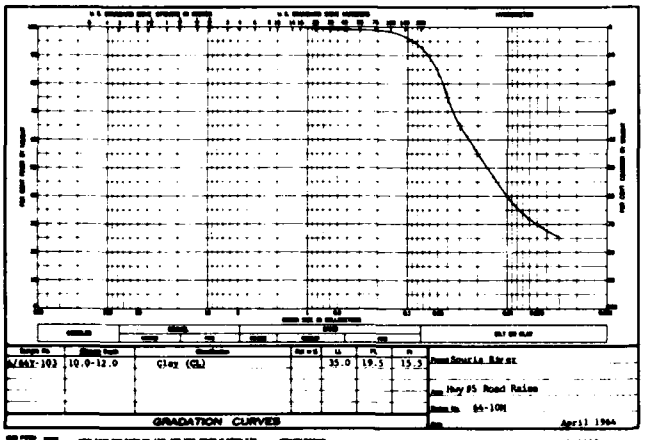


FIGURE 23

①

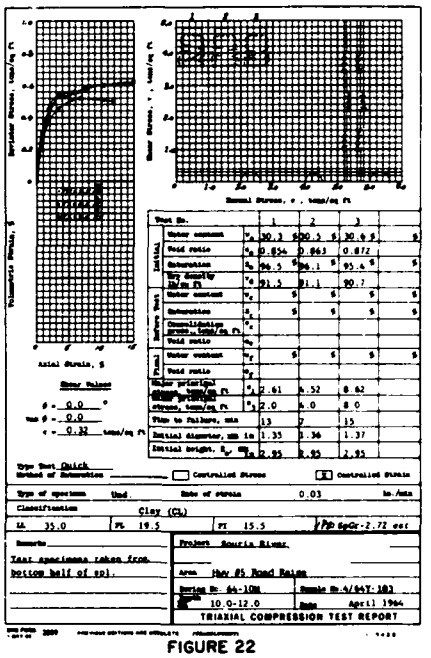
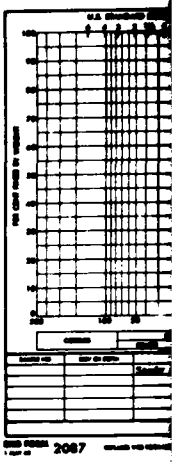


FIGURE 22

②



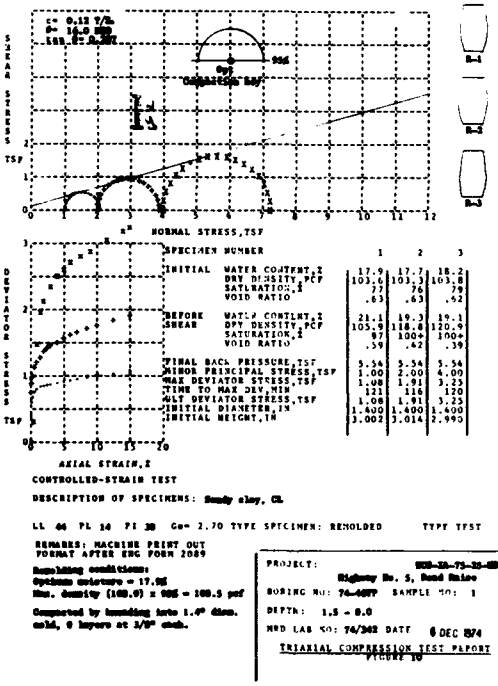


FIGURE 10

⑤

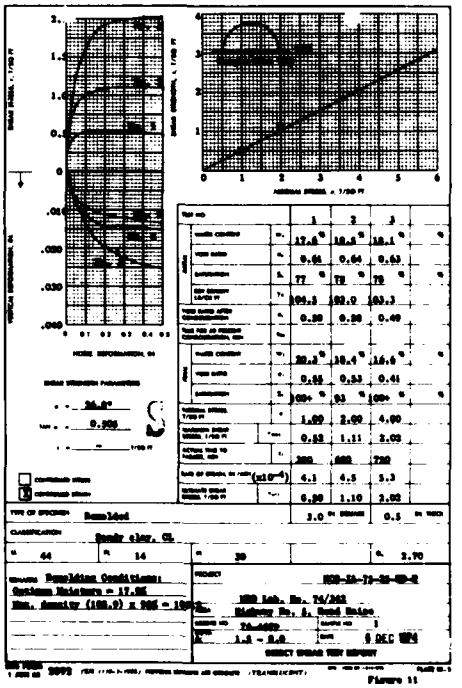
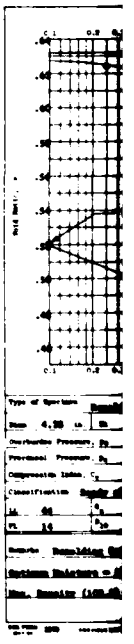
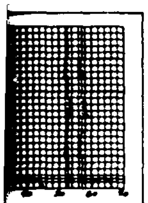
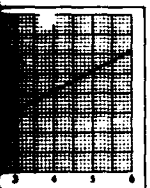


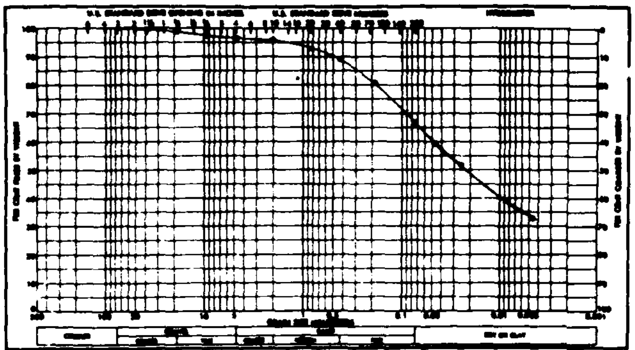
Figure 11

⑥









		Sandy clay, CL		41	14	27

Highway No. 5

NCS-IA-75-25-ED-8

Hole 74-46 TP-1

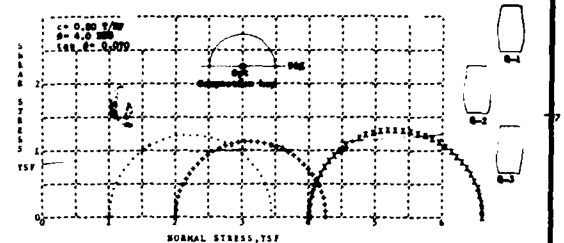
NED Lab. No. 74/342

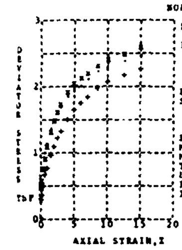
14 NOV

2087

Figure 2

③





SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT, %	16.7	17.6	17.5
	DRY DENSITY, PCF	104.4	104.6	104.1
	SATURATION, %	74	78	77
	VOID RATIO	.61	.61	.62
BEFORE SHEAR	WATER CONTENT, %	16.6	17.5	17.4
	DRY DENSITY, PCF	105.4	106.7	110.2
	SATURATION, %	75	81	89
	VOID RATIO	.60	.58	.53
FINAL BACK PRESSURE, TSF		.00	.00	.00
MINOR PRINCIPAL STRESS, TSF		1.00	2.00	4.00
MAX DEVIATOR STRESS, TSF		2.45	2.26	2.60
TIME TO MAX DEV, MIN		36	32	29
ULT DEVIATOR STRESS, TSF		2.45	2.26	2.60
INITIAL DIAMETER, IN		1.399	1.399	1.399
INITIAL HEIGHT, IN		2.998	2.985	2.987

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

LL 44 PL 14 PI 30 Gs= 2.70 TYPE SPECIMEN: REMOLDED TYPE TEST Q

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENC FORM 2089

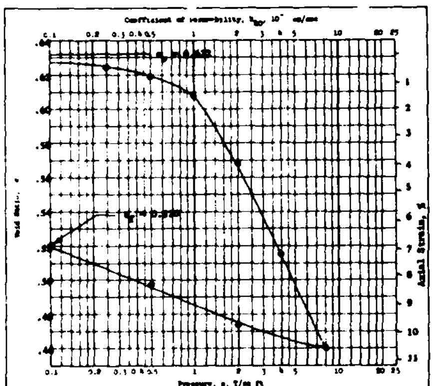
Remolding Conditions:
Optimum moisture = 17.9%
Max. density (108.9) x 96% = 104.5 pcf

Compacted by pounding into 1.4" diam. mold, 6 layers at 3/8" each.

PROJECT: NCS-IA-75-25-ED-8
Highway No. 5, Road Raise
BORING NO: 74-46TP SAMPLE NO: 1
DEPTH: 1.5 - 8.0
NED LAB NO: 74/342 DATE 6 DEC 1974

TRIAXIAL COMPRESSION TEST REPORT
FIGURE 9

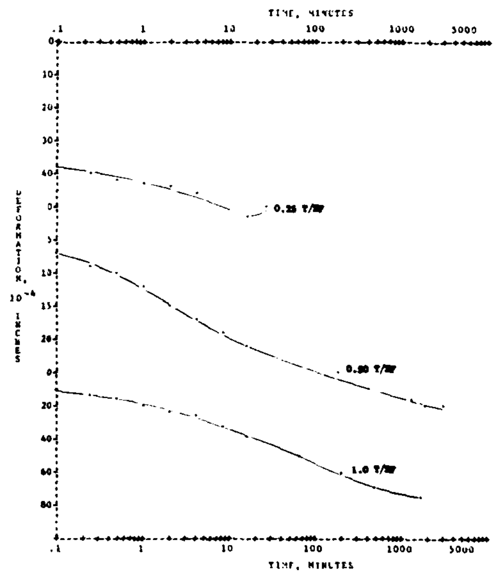
④



Type of Specimen Remolded		Before Test		After Test	
Diam 4.38 in.	Ht 1.00 in.	Water Content, w_o	18.2 %	w_f	18.6 %
Overburden Pressure, p_o T/sq ft		Void Ratio, e_o	0.632	e_f	0.520
Preconsol. Pressure, p_c T/sq ft		Saturation, S_o	77 %	S_f	100 %
Compression Index, C_c		Dry Density, γ_d	103.5 lb/ft³		
Classification Sandy clay, CL		k_{20} at e_o = × 10⁻ cm/sec			
LL 44	G_s 2.70	Project NCS-IA-75-25-ED-8			
PL 14	D_{10}	NED Lab. No. 74/342			
Remarks Remolding Conditions:		Area Highway No. 5, Road Raise			
Optimum Moisture = 17.9%		Boring No. 74-46TP		Sample No. 1	
Max. Density (108.9) x 96%=104.5		Depth 1.5 - 8.0		Date 6 DEC 1974	
		CONSOLIDATION TEST REPORT			

Figure 12

⑦



PROJECT: NCS-IA-75-25-ED-8
NED LABORATORY NO: 74/342 Highway No. 5, Road Raise
BORING NO: 74-46TP SAMPLE NO: 1 DEPTH: 1.5 - 8.0 DATE: 6 DEC 1974

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT FORMAT AFTER ENG FORM 2088

FIGURE 13a

⑧

DESIGN MEMORANDUM NO. 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

SOILS TEST DATA
STATE HIGHWAY NO. 5

BORINGS 64-10M AND 74-46TP

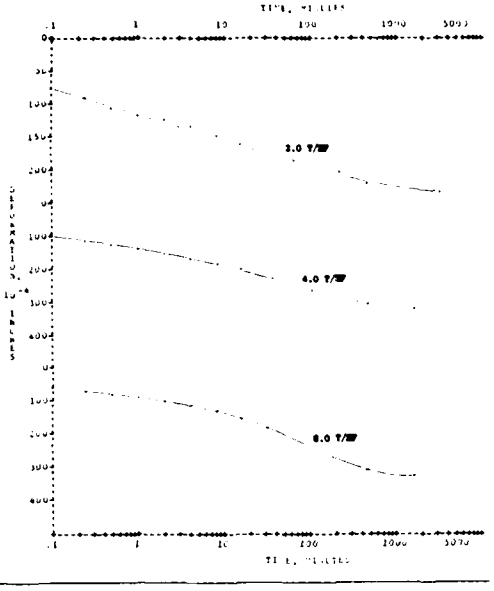
ST. PAUL, MINN. DISTRICT

JUNE 1983

RI-R-S/775

PLATE NO. 8-76

CORPS OF ENGINEERS



PROJECT: NCE-IA-75-35-ED-H

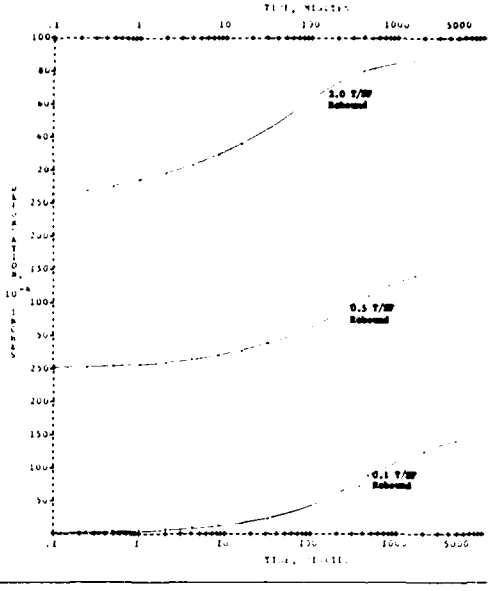
WES LABORATORY NO: 74/343 Highway No. 5, Road Raise

BORING NO: 74-4677 SAMPLE NO: 1 DEPTH: 1.5 - 8.0 DATE: 6 DEC 1974

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2086 FIGURE 12b

①



PROJECT: NCE-IA-75-35-ED-H

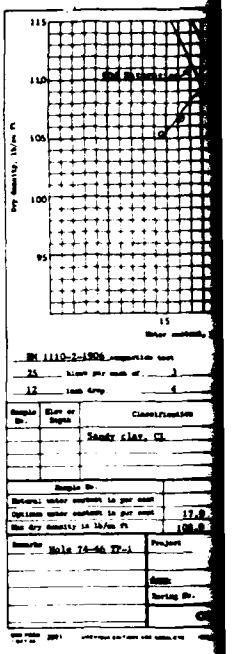
WES LABORATORY NO: 74/343 Highway No. 5, Road Raise

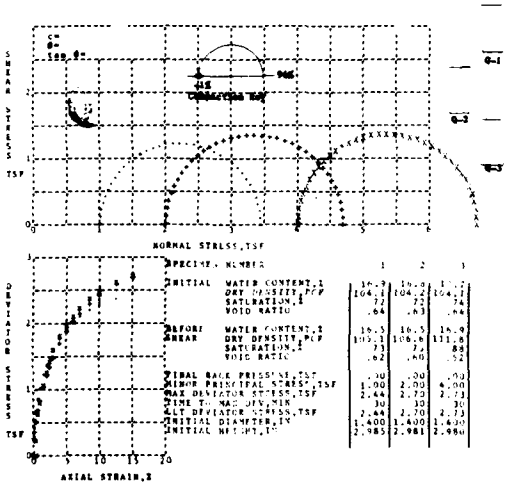
BORING NO: 74-4677 SAMPLE NO: 1 DEPTH: 1.5 - 8.0 DATE: 6 DEC 1974

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2086 FIGURE 12c

②





SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT, %	16.9	16.9	16.9
	DRY DENSITY, PCF	104.1	104.2	104.1
	SATURATION, %	72	73	74
	VOID RATIO	.64	.63	.64
BEFORE SHEAR	WATER CONTENT, %	16.5	16.5	16.9
	DRY DENSITY, PCF	103.1	106.6	111.8
	SATURATION, %	73	77	88
	VOID RATIO	.62	.60	.52
FINAL RATE PRINCIPAL STRESS, TSF		.00	.00	.00
MINOR PRINCIPAL STRESS, TSF		1.00	2.00	4.00
MAX DEVIATOR STRESS, TSF		2.44	2.73	2.73
TIME T- MAX DEV, MIN		30	30	30
ULT DEVIATOR STRESS, TSF		2.44	2.70	2.73
INITIAL DIAMETER, IN		1.400	1.400	1.400
INITIAL HEIGHT, IN		2.985	2.981	2.980

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMEN: Sandy clay, CL

LL 27 PL 12 PI 15 Gs= 2.73 TYPE SPECIMEN: REMOLDED TYPE TEST: Q

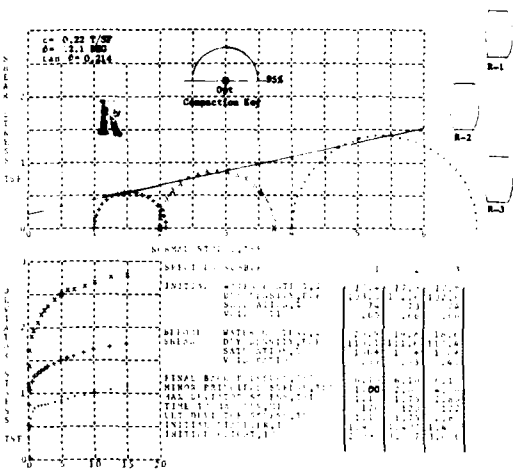
REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

Remolding Conditions:
Opt. moisture (17.9) -1% = 16.9%
Max. density (108.1) x 96% = 103.8 pcf

Compacted by kneading into 1.4" diam. mold, 8 layers at 3/8" each.

PROJECT: NCE-IA-75-35-ED-H
Highway No. 5, Road Raise
B RING NO: 74-4677 SAMPLE NO: 5
DEPTH: 8.0 - 14.5
M . LAB NO: 74/343 DATE 6 DEC 1974
TRIAXIAL COMPRESSION TEST REPORT
FIGURE 13

⑤



CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMEN: Sandy clay, CL

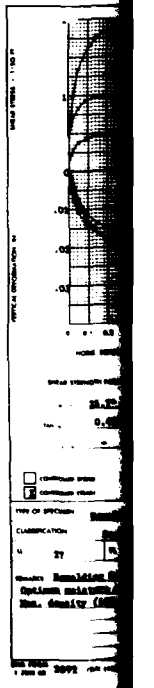
REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

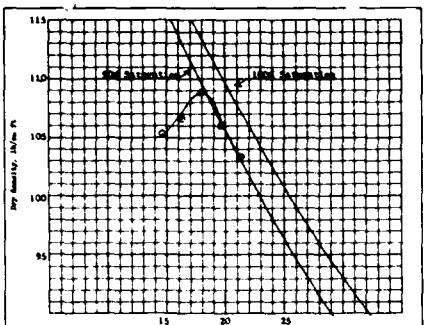
Remolding Conditions:
Optimum Moisture = 17.9%
Max. Density (108.1) x 92% = 100.7 pcf

Compacted by kneading into 1.4" diam. mold, 8 layers at 3/8" each.

PROJECT: NCE-IA-75-35-ED-H
Highway No. 5, Road Raise
B RING NO: 74-4677 SAMPLE NO: 5
DEPTH: 8.0 - 14.5
M . LAB NO: 74/343 DATE 6 DEC 1974
TRIAXIAL COMPRESSION TEST REPORT
FIGURE 14

⑥





EM 1110-2-1906 compaction test

25 blows per each of 3 layers, with 5.5 lb rammer and

12 inch drop. 4 inch diameter mold

Sample No.	Elev. or Depth	Classification	G	LL	PL	% > No. 4	% > 1½ in.
		Sandy clay, CL	2.70	41	14	3.4	1.5

Sample No.	
Natural water content in per cent	
Optimum water content in per cent	17.9
Max dry density in lb/cu. ft	108.9

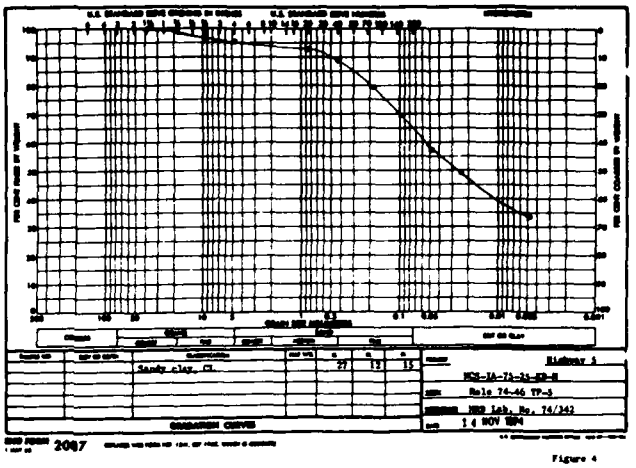
Remarks: Mole 74-46 TP-1

Project: Highway No. 5
NCS-IA-75-25-RD-H
HRD Lab. No. 74/342
Boring No. Date 14 NOV 1974

COMPACTION TEST REPORT

Figure 1

③



Project: Highway 5
NCS-IA-75-25-RD-H
Mole 74-46 TP-5
HRD Lab. No. 74/342
14 NOV 1974

Figure 4

④

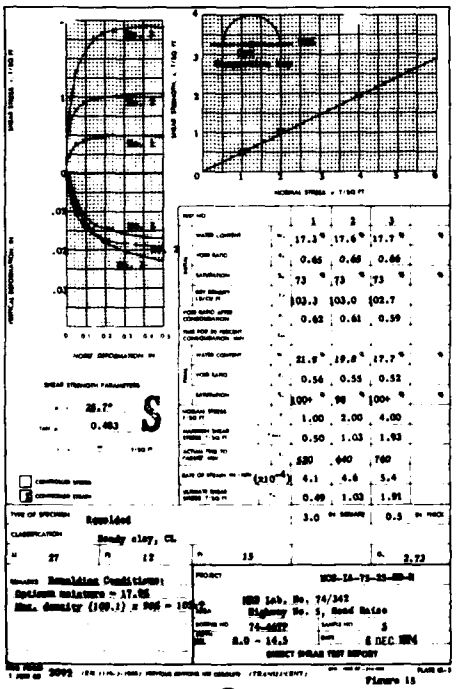
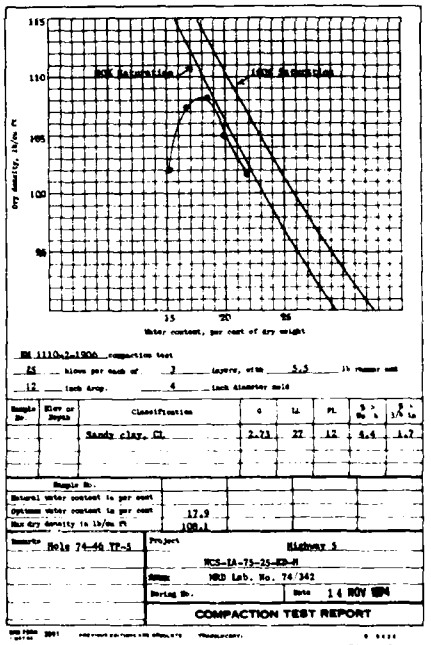


Figure 15

⑦



EM 1110-2-1906 compaction test

25 blows per each of 3 layers, with 5.5 lb rammer and

12 inch drop. 4 inch diameter mold

Sample No.	Elev. or Depth	Classification	G	LL	PL	% > No. 4	% > 1½ in.
		Sandy clay, CL	2.73	27	12	6.4	1.7

Sample No.	
Natural water content in per cent	
Optimum water content in per cent	17.9
Max dry density in lb/cu. ft	108.1

Remarks: Mole 74-46 TP-5

Project: Highway 5
NCS-IA-75-25-RD-H
HRD Lab. No. 74/342
Boring No. Date 14 NOV 1974

COMPACTION TEST REPORT

Figure 3

⑧

DESIGN MEMORANDUM NO. 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
SOILS TEST DATA
STATE HIGHWAY NO. 5
BORING 74-46TP
ST PAUL, MINN DISTRICT
JUNE 1983

RI-R-8/776

PLATE NO. B-77

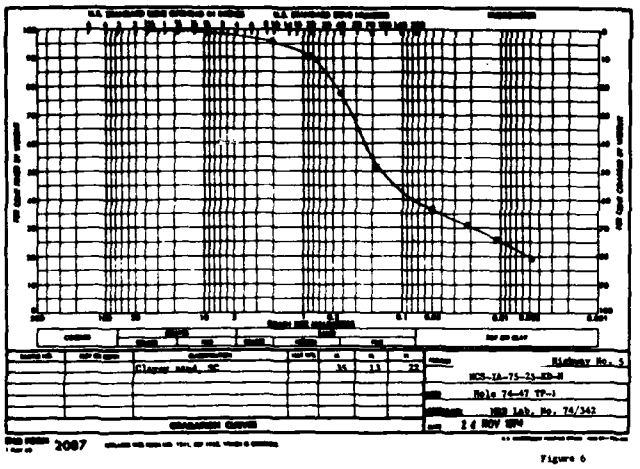
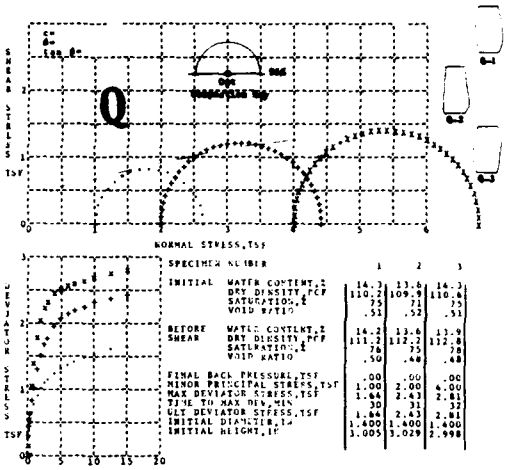


Figure 4

①



SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT,%	14.3	13.6	14.3
	DRY DENSITY,PCF	110.2	109.9	110.6
	SATURATION,%	75	71	75
	VOID RATIO	.51	.52	.51
BEFORE SHEAR	WATER CONTENT,%	14.2	13.6	13.9
	DRY DENSITY,PCF	111.2	112.2	112.8
	SATURATION,%	76	75	78
	VOID RATIO	.50	.48	.48
FINAL BACK PRESSURE,TSF		.00	.00	.00
MINOR PRINCIPAL STRESS,TSF		1.00	2.00	4.00
MAX DEVIATOR STRESS,TSF		1.64	2.43	2.81
TIME TO MAX DEV.,MIN		30	31	32
ULT DEVIATOR STRESS,TSF		1.64	2.43	2.81
INITIAL DIAMETER,IN		1.400	1.400	1.400
INITIAL HEIGHT,IN		3.005	3.029	2.998

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Clayey sand, SC

LL 35 PL 13 PI 22 Gs= 2.67 TYPE SPECIMEN: Remolded TYPE TEST U

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2089

Remolding conditions:
Optimum moisture = 13.9%
Max. density (117.2) x 95% = 111.3 pcf

Compacted by kneading into 1.4" diam. mold, 8 layers at 3/8" each.

PROJECT: HCS-1A-75-25-RD-H
Highway No. 5, Road Raise
BORING NO: 74-47TP SAMPLE NO: 1
DEPTH: 1.6 - 8.0
HRD LAB NO: 74/342 DATE 18 DEC 1974

TRIAXIAL COMPRESSION TEST REPORT
FIGURE 8

②

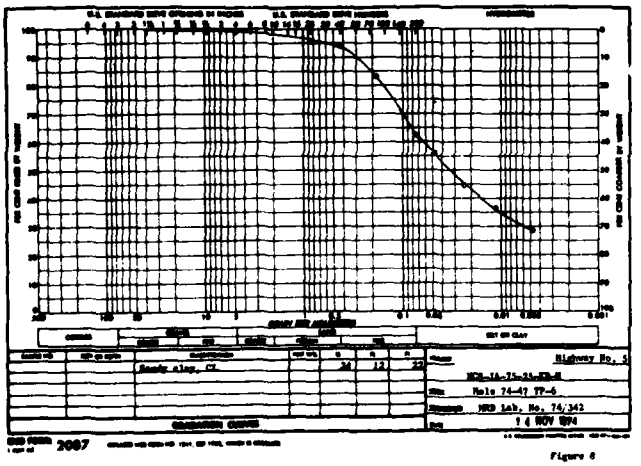
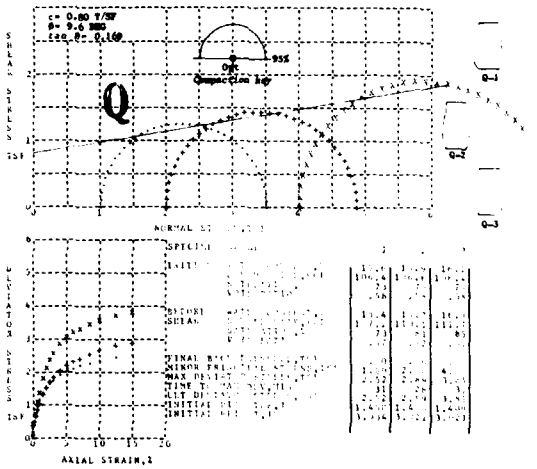


Figure 8

⑤



CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2089

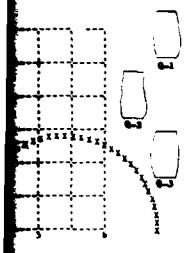
Remolding conditions:
Optimum moisture = 16.3%
Max. density (112.9) x 95% = 107.3 pcf

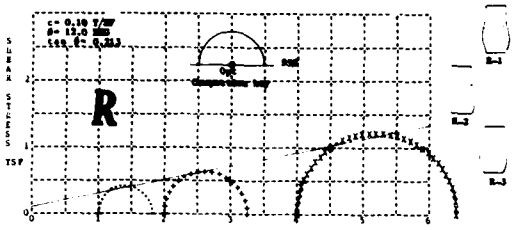
Compacted by kneading into 1.4" diam. mold, 8 layers at 3/8" each.

PROJECT: HCS-1A-75-25-RD-H
Highway No. 5, Road Raise
BORING NO: 74-47TP SAMPLE NO: 6
DEPTH: 8.0 - 14.0
HRD LAB NO: 74/342 DATE 17 JAN 1975

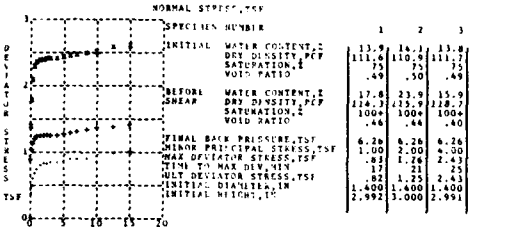
TRIAXIAL COMPRESSION TEST REPORT
FIGURE 9

⑥





	1	2	3
	16.3	15.6	16.3
	110.2	109.9	110.6
	.75	.71	.75
	.51	.52	.51
	16.2	13.6	13.9
	122.2	122.2	122.8
	.76	.75	.78
	.50	.48	.48
	.00	.00	.00
	1.00	2.00	4.00
	2.64	2.43	2.81
	.30	.11	.32
	1.64	2.43	2.81
	1.400	1.400	1.400
	3.005	3.029	2.998



SPECIMEN NUMBER

		1	2	3
INITIAL	WATER CONTENT,%	13.9	14.1	13.8
	DRY DENSITY,PCF	111.6	110.6	111.7
	SATURATION,%	.75	.75	.75
	VOID RATIO	.49	.50	.49
BEFORE SHEAR	WATER CONTENT,%	17.6	23.9	15.9
	DRY DENSITY,PCF	114.3	113.9	118.7
	SATURATION,%	100+	100+	100+
	VOID RATIO	.46	.44	.40
FINAL BACK PRESSURE,TSF		6.26	6.26	6.26
MINOR PRINCIPAL STRESS,TSF		1.00	2.00	4.00
MAX DEVIATOR STRESS,TSF		.83	1.74	2.43
TIME TO MAX DEV,MIN		17	21	25
ULT DEVIATOR STRESS,TSF		.82	1.25	2.43
INITIAL DIALITE,IN		1.400	1.400	1.400
INITIAL HEIGHT,IN		2.992	3.000	2.991

AXIAL STRAIN,%

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Clayey sand, SC

LL 35 PL 13 PI 22 Gs= 2.67 TYPE SPECIMEN: REMOLDED TYPE TEST R

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

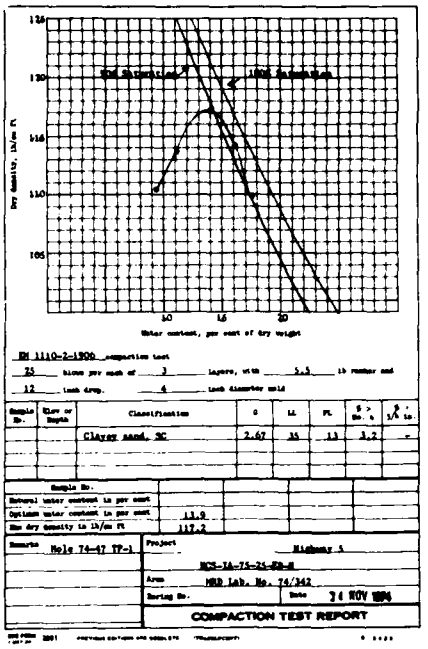
Remolding Conditions:
Optimum moisture = 13.9%
Max. density (117.2) x 95% = 111.3 pcf

Compacted by kneading into 1.4" diam. mold, 8 layers at 3/8" each.

PROJECT: MCS-1A-75-25-RD-H
Highway No. 5, Road Raise
BORING NO: 74-47TP SAMPLE NO: 1
DEPTH: 1.0 - 8.0
MRD LAB NO: 74/342 DATE 18 DEC 1974

TRIAXIAL COMPRESSION TEST REPORT
FIGURE 10

③



Wet density, lb/cu ft

Water content, per cent of dry weight

EM 1110-2-1906 compaction test

25 blows per each of 3 layers, with 5.5 lb rammer and
12 inch drop. 4 inch diameter mold

Sample No.	Elev or Depth	Classification	G	LL	PL	% > No. 4	% < .074 mm
		Clayey sand, SC	2.67	35	13	3.2	-

Sample No.
Natural water content in per cent
Optimum water content in per cent 13.9
Max dry density in lb/cu ft 117.2

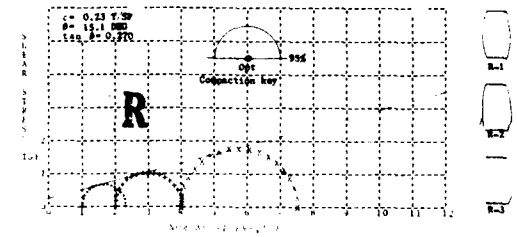
Remarks: Hole 74-47 TP-1

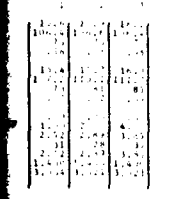
Project: Highway 5
MCS-1A-75-25-RD-H
Area: MRD Lab. No. 74/342
Boring No. Date 24 NOV 1974

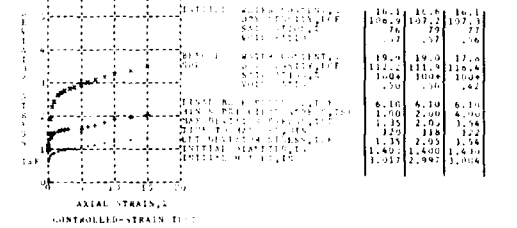
COMPACTION TEST REPORT

Figure 5

④







SPECIMEN NUMBER

		1	2	3
INITIAL	WATER CONTENT,%	16.3	16.1	16.1
	DRY DENSITY,PCF	106.9	107.2	107.3
	SATURATION,%	76	79	77
	VOID RATIO	.57	.57	.56
BEFORE SHEAR	WATER CONTENT,%	19.0	19.0	17.6
	DRY DENSITY,PCF	112.1	111.9	110.4
	SATURATION,%	100+	100+	100+
	VOID RATIO	.50	.50	.52
FINAL BACK PRESSURE,TSF		6.10	6.10	6.10
MINOR PRINCIPAL STRESS,TSF		1.00	2.00	4.00
MAX DEVIATOR STRESS,TSF		1.35	2.0	3.54
TIME TO MAX DEV,MIN		120	118	122
ULT DEVIATOR STRESS,TSF		1.35	2.03	3.54
INITIAL DIALITE,IN		1.40	1.400	1.419
INITIAL HEIGHT,IN		3.017	2.997	3.004

AXIAL STRAIN,%

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

LL 34 PL 12 PI 22 Gs= 2.67 TYPE SPECIMEN: REMOLDED TYPE TEST R

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

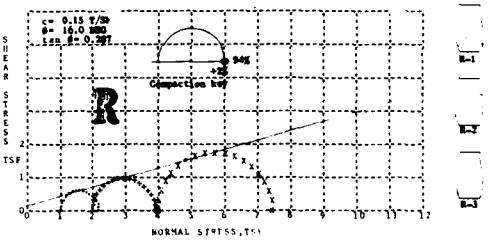
Remolding conditions:
Optimum moisture = 16.3%
Max. density (112.9) x 95% = 107.2 pcf

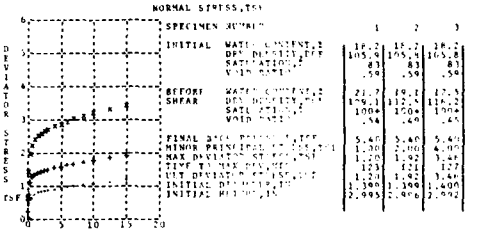
Compacted by kneading into 1.4" diam. mold, 8 layers at 3/8" each.

PROJECT: MCS-1A-75-25-RD-H
Highway No. 5, Road Raise
BORING NO: 74-47TP SAMPLE NO: 6
DEPTH:
MRD LAB NO: 74/342 DATE 17 JAN 1975

TRIAXIAL COMPRESSION TEST REPORT
FIGURE 11

⑦





SPECIMEN NUMBER

		1	2	3
INITIAL	WATER CONTENT,%	16.2	15.7	16.1
	DRY DENSITY,PCF	105.6	105.5	105.8
	SATURATION,%	.83	.83	.83
	VOID RATIO	.59	.59	.58
BEFORE SHEAR	WATER CONTENT,%	21.7	19.1	17.5
	DRY DENSITY,PCF	109.1	112.5	114.3
	SATURATION,%	100+	100+	100+
	VOID RATIO	.54	.49	.45
FINAL BACK PRESSURE,TSF		5.40	5.40	5.40
MINOR PRINCIPAL STRESS,TSF		1.30	2.700	4.00
MAX DEVIATOR STRESS,TSF		1.20	1.92	3.44
TIME TO MAX DEV,MIN		123	121	127
ULT DEVIATOR STRESS,TSF		1.20	1.92	3.44
INITIAL DIALITE,IN		1.390	1.390	1.400
INITIAL HEIGHT,IN		2.995	2.996	2.992

AXIAL STRAIN,%

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

LL 34 PL 12 PI 22 Gs= 2.67 TYPE SPECIMEN: REMOLDED TYPE TEST R

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

Remolding conditions:
Opt. moisture (16.3) +2% = 18.3%
Max. density (112.9) x 94% = 106.1 pcf

Compacted by kneading into 1.4" diam. mold, 8 layers at 3/8" each.

PROJECT: MCS-1A-75-25-RD-H
Highway No. 5, Road Raise
BORING NO: 74-47TP SAMPLE NO: 6
DEPTH: 8.0 - 14.0
MRD LAB NO: 74/342 DATE 17 JAN 1975

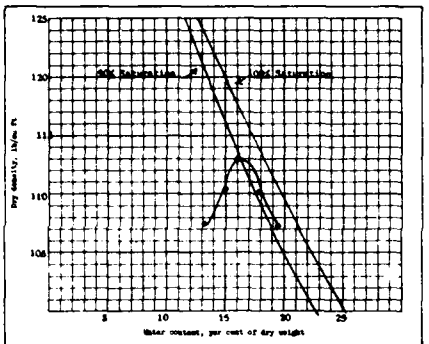
TRIAXIAL COMPRESSION TEST REPORT
FIGURE 10

⑧

DESIGN MEMORANDUM NO. 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
SOILS TEST DATA
STATE HIGHWAY NO. 5
BORING 74-47TP
ST PAUL, MINN DISTRICT
JUNE 1983

RI-R-8/777

PLATE NO 8-78



EM 1110-2-1906 compaction test

25 blows per coat of 3 layers, with 5.5 lb rammer and

12 inch drop. 4 inch diameter mold

Sample No.	Elev or Depth	Classification	G	LL	PL	% > No. 4	% > 3/4 in.
		Sandy clay, CL	2.69	34	12	1.3	-

Sample No.	
Natural water content in per cent	
Optimum water content in per cent	16.3
Max dry density in lb/cu ft	112.9

Remarks: Hole 74-47 TP-6

Project: Highway No. 5

NCS-IA-75-25-ED-H

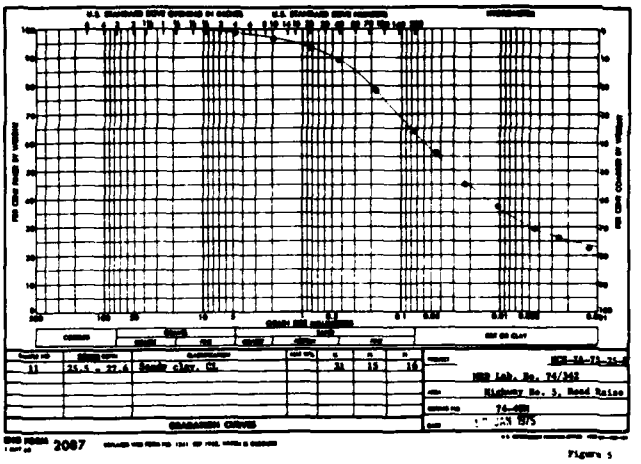
MRD Lab. No. 74/342

Boring No. Date 14 NOV 1974

COMPACTION TEST REPORT

Figure 7

①



Sample No.	Boring No.	Depth	Classification	LL	PL	PI
11		25.5 - 27.6	Sandy clay, CL	34	18	16

Project: NCS-IA-75-25-ED-H

MRD Lab. No. 74/342

Area: Highway No. 5, Bend Raise

Sample No. 74-48B

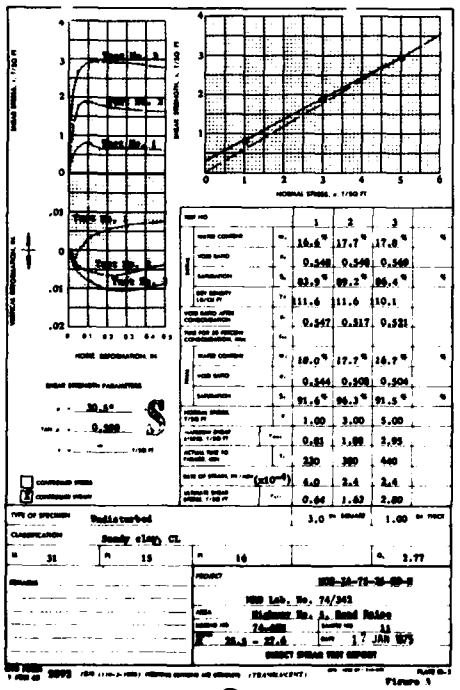
Date: 17 JAN 1975

GRADATION CURVE

ENG FORM 2087

Figure 5

②



TEST NO.		1	2	3	
INITIAL	WATER CONTENT, %	16.6	17.7	17.8	%
	VOID RATIO	0.548	0.540	0.540	
	SATURATION, %	83.9	89.2	89.4	%
	DRY DENSITY, lb/cu ft	111.6	111.6	110.1	
	VOID RATIO AFTER CONSOLIDATION	0.547	0.517	0.521	
TEST FOR 24 HOURS CONSOLIDATION, After					
FINAL	WATER CONTENT, %	18.0	17.7	16.7	%
	VOID RATIO	0.544	0.498	0.504	
	SATURATION, %	91.6	96.3	91.5	%
NORMAL STRESS, T/SQ FT	σ	1.00	3.00	5.00	
VERTICAL DEFORM. AT FAILURE, IN.	Δ_f	0.81	1.89	2.95	
ACTUAL TIME TO FAILURE, MIN.	t_f	330	380	440	
RATE OF STRAIN, IN/MIN	$(\times 10^{-4})$	4.0	2.4	2.4	
ULTIMATE SHEAR STRESS, T/SQ FT	τ_f	0.66	1.63	2.80	

Shear strength parameters: ϕ = 30.5°, c = 0.300 T/SQ FT

TYPE OF SPECIMEN: Undisturbed — 3.0 IN. SQUARE — 1.00 IN. THICK

CLASSIFICATION: Sandy clay, CL

LL	PI	PL	G_s
31	15	16	2.77

Project: NCS-IA-75-25-ED-H

MRD Lab. No. 74/342

Area: Highway No. 5, Bend Raise

Sample No. 74-48B

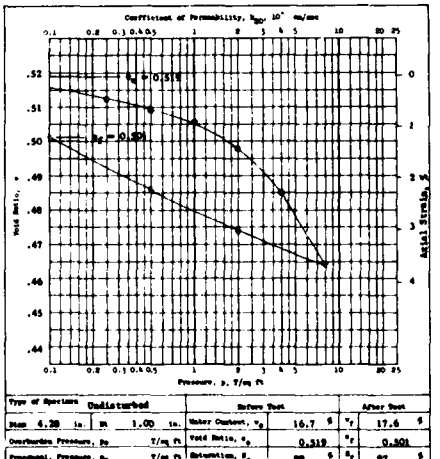
Depth: 25.5 - 27.6

Date: 17 JAN 1975

DIRECT SHEAR TEST REPORT

Figure 5

⑤



Type of Specimen: Undisturbed		Before Test		After Test	
Diam 4.29 in.	H 1.00 in.	Water Content, w_o	16.7 %	w_f	17.6 %
Overburden Pressure, p_o T/sq ft		Void Ratio, e_o	0.519	e_f	0.501
Preconsol. Pressure, p_c T/sq ft		Saturation, S_o	89 %	S_f	97 %
Compression Index, C_c		Dry Density, γ_d	113 lb/ft³		
Classification: Sandy clay, CL		k_{20} at e_o =	= 10^{-7} cm/sec		
LL 31	G_s 2.77				
PL 15	D_{10}				

Remarks:

Project: NCS-IA-75-25-ED-H

MRD Lab. No. 74/342

Area: Highway No. 5, Bend Raise

Boring No. 74-48B Sample No. 11

Depth: 25.5 - 27.6 Date: 17 JAN 1975

CONSOLIDATION TEST REPORT

Figure 4

⑥

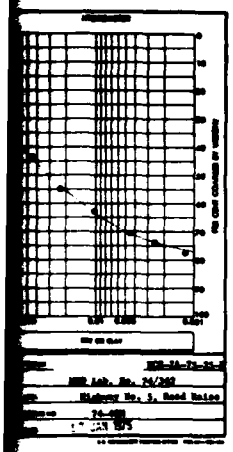
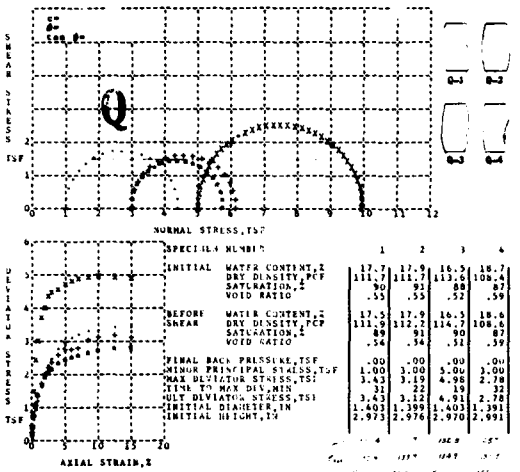


Figure 5



SPECIMEN NUMBER		1	2	3	4
INITIAL	WATER CONTENT, %	17.7	17.9	16.5	18.7
	DRY DENSITY, PCF	111.7	111.7	113.6	108.4
	SATURATION, %	90	91	88	87
	VOID RATIO	.55	.55	.52	.59
BEFORE SHEAR	WATER CONTENT, %	17.5	17.9	16.5	18.6
	DRY DENSITY, PCF	111.9	112.2	114.7	108.6
	SATURATION, %	89	91	90	87
	VOID RATIO	.54	.54	.51	.59
FINAL BACK PRESSURE, TSF		.00	.00	.00	.00
MINOR PRINCIPAL STRESS, TSF		1.00	3.00	5.00	3.00
MAX DEVIATOR STRESS, TSF		3.43	3.19	4.98	2.78
TIME TO MAX DEV, MIN		31	22	19	32
ULT DEVIATOR STRESS, TSF		3.43	3.12	4.91	2.78
INITIAL DIAMETER, IN		1.403	1.399	1.403	1.391
INITIAL HEIGHT, IN		2.973	2.976	2.970	2.991

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: **Sandy clay, CL**

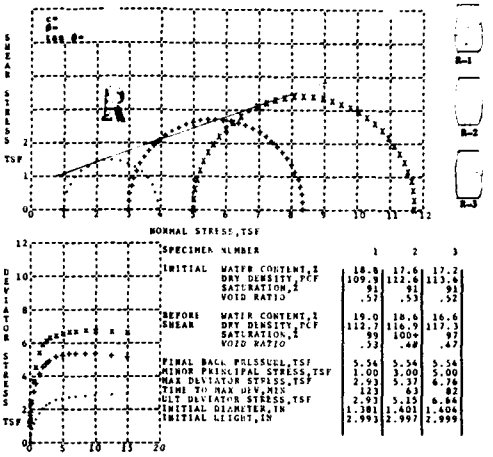
LL 31 PL 15 PI 16 Gs= 2.77 TYPE SPECIMEN: UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2039

Mod. brown sandy clay, some sand and gravel pockets. Brittle structure, stiff consistency, insensitive, medium toughness at PL, no shine, sluggish shake reaction.

PROJECT: MCS-IA-75-25-SD-S
Highway No. 5, Road Raise
BORING NO: 74-46M SAMPLE NO: 11
DEPTH: 25.5 – 27.6
MRD LAB NO: 74/342 DATE 17 JAN 1975
TRIAXIAL COMPRESSION TEST REPORT
FIGURE 3

③



SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT, %	18.8	17.6	17.2
	DRY DENSITY, PCF	109.9	113.6	113.6
	SATURATION, %	91	91	91
	VOID RATIO	.57	.53	.52
BEFORE SHEAR	WATER CONTENT, %	19.0	18.6	16.6
	DRY DENSITY, PCF	112.7	116.9	117.3
	SATURATION, %	99	100+	97
	VOID RATIO	.53	.48	.47
FINAL BACK PRESSURE, TSF		5.56	5.56	5.56
MINOR PRINCIPAL STRESS, TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS, TSF		2.93	5.37	6.76
TIME TO MAX DEV, MIN		123	63	82
ULT DEVIATOR STRESS, TSF		2.93	5.15	6.84
INITIAL DIAMETER, IN		1.381	1.401	1.404
INITIAL HEIGHT, IN		2.993	2.997	2.999

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: **Sandy clay, CL**

LL 31 PL 15 PI 16 Gs= 2.77 TYPE SPECIMEN: UNDISTURBED TYPE TEST R

REMARKS: MACHINE PRINT OUT FORMAT AFTER ENG FORM 2039

PROJECT: MCS-IA-75-25-SD-S
Highway No. 5, Road Raise
BORING NO: 74-46M SAMPLE NO: 11
DEPTH: 25.5 – 27.6
MRD LAB NO: 74/342 DATE 17 JAN 1975
TRIAXIAL COMPRESSION TEST REPORT
FIGURE 4

④

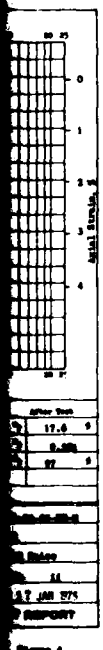
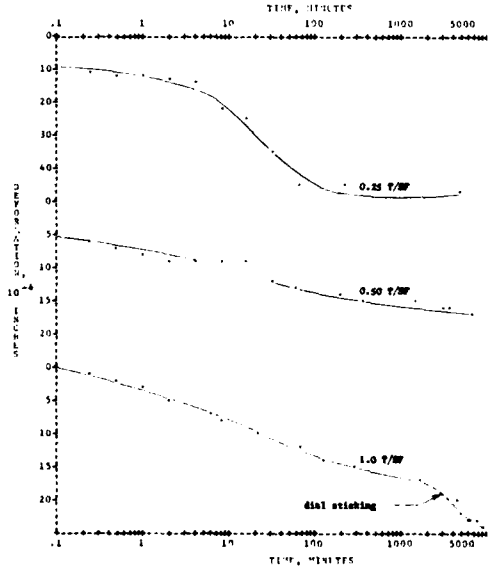
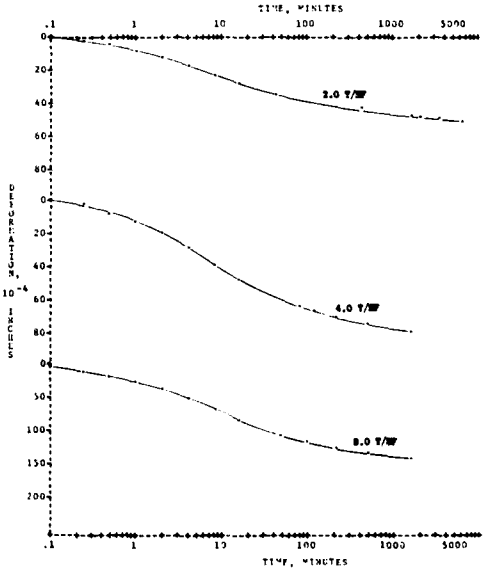


Figure 4



PROJECT: MCS-IA-75-25-SD-S
MRD LABORATORY NO: 74/342 Highway No. 5, Road Raise
BORING NO: 74-46M SAMPLE NO: 11 DEPTH: 25.5 – 27.6 DATE: 17 JAN 1975
CONSOLIDATION TEST -- TIME CURVES
MACHINE PRINT OUT FORMAT AFTER ENG FORM 2038 FIGURE 4a

⑦

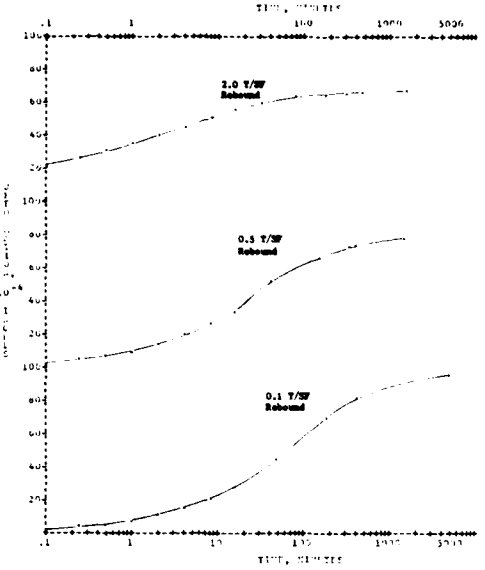


PROJECT: MCS-IA-75-25-SD-S
MRD LABORATORY NO: 74/342 Highway No. 5, Road Raise
BORING NO: 74-46M SAMPLE NO: 11 DEPTH: 25.5 – 27.6 DATE: 17 JAN 1975
CONSOLIDATION TEST -- TIME CURVES
MACHINE PRINT OUT FORMAT AFTER ENG FORM 2038 FIGURE 4b

⑧

DESIGN MEMORANDUM NO. 3 GENERAL
FLOOD CONTROL – LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
SOILS TEST DATA
STATE HIGHWAY NO. 5
BORINGS 74-47TP AND 74-49M
ST. PAUL, MINN. DISTRICT
JUNE 1983

RI-R-8/778 PLATE NO. 8-79



PROJECT: HCB-1A-75-25-ED-H

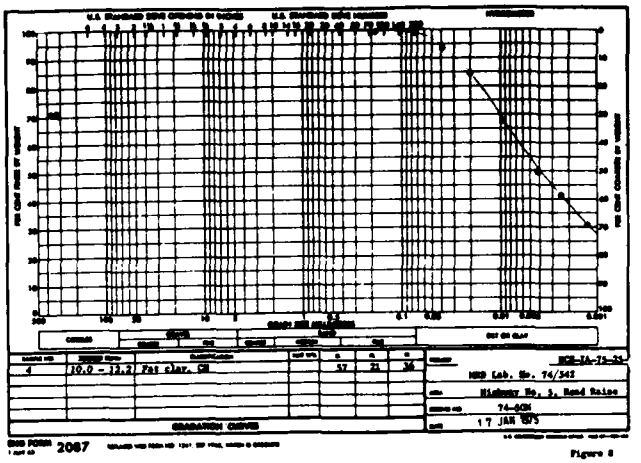
NBD LABORATORY NO: 74/342 Highway No. 5, Road Raise

BORING NO: 74-6GH SAMPLE NO: 11 DEPTH: 25.5 - 27.6 DATE: 17 JAN 75

CONSOLIDATION TEST -- TIME CURVE

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2086 TEST NO 4c

①

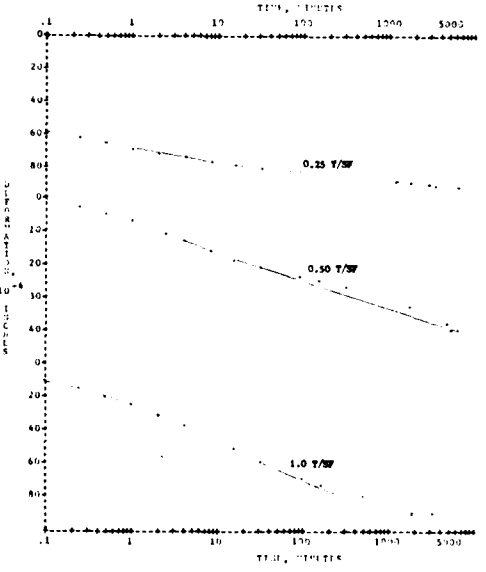


4	10.0 - 12.2 Fat clay, CH		57	23	34

HCB-1A-75-25-H
NBD Lab. No. 74/342
Highway No. 5, Road Raise
74-6GH
17 JAN 1975

ENG FORM 2087 Figure 8

②



PROJECT: HCB-1A-75-25-ED-H

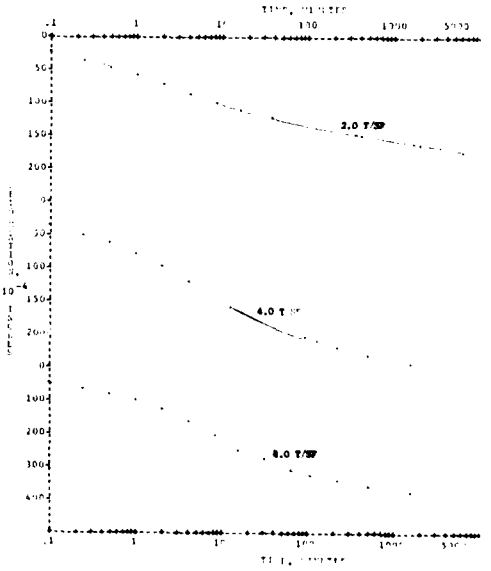
NBD LABORATORY NO: 74/342 Highway No. 5, Road Raise

BORING NO: 74-6GH SAMPLE NO: 4 DEPTH: 10.0 - 12.2 DATE: 17 JAN 1975

CONSOLIDATION TEST -- TIME CURVE

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2086 TEST NO 7a

⑤



PROJECT: HCB-1A-75-25-ED-H

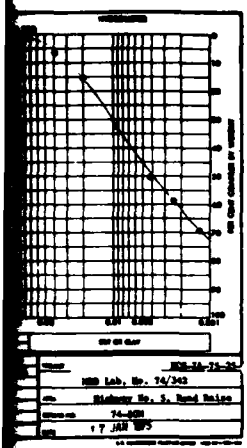
NBD LABORATORY NO: 74/342 Highway No. 5, Road Raise

BORING NO: 74-6GH SAMPLE NO: 4 DEPTH: 10.0 - 12.2 DATE: 17 JAN 1975

CONSOLIDATION TEST -- TIME CURVE

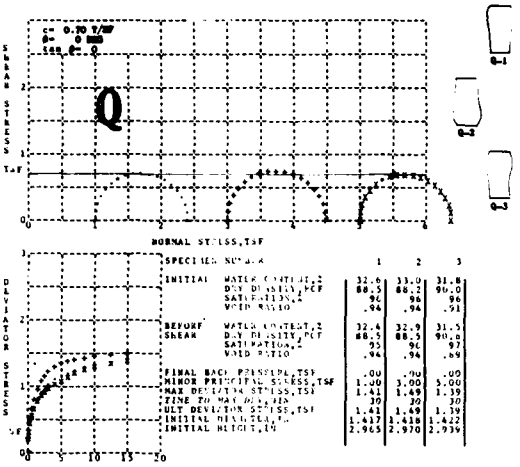
MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2086 TEST NO 7b

⑥



MRD Lab. No. 74/342
Highway No. 5, Road Raise
74-50M
17 JAN 1975

Figure 6



SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT,%	32.6	33.0	31.8
	DRY DENSITY,PCF	88.5	88.2	90.0
	SATURATION,%	96	96	96
	VOID RATIO	.94	.94	.91
BEFORE SHEAR	WATER CONTENT,%	32.6	32.9	31.5
	DRY DENSITY,PCF	88.5	88.5	90.0
	SATURATION,%	93	96	97
	VOID RATIO	.94	.94	.89
FINAL BACK PRESSURE,TSF		.00	.00	.00
MINOR PRINCIPAL STRESS,TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS,TSF		1.41	1.49	1.39
TIME TO MAX DEVIATOR		30	30	30
ULT DEVIATOR STRESS,TSF		1.41	1.49	1.39
INITIAL DIAMETER,IN		1.417	1.418	1.422
INITIAL HEIGHT,IN		2.965	2.970	2.939

AXIAL STRAIN,%

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Fat clay, CH

LL 57 PL 21 PI 36 Gs= 2.75 TYPE SPECIMENS: UNDISTURBED TYPE TEST Q

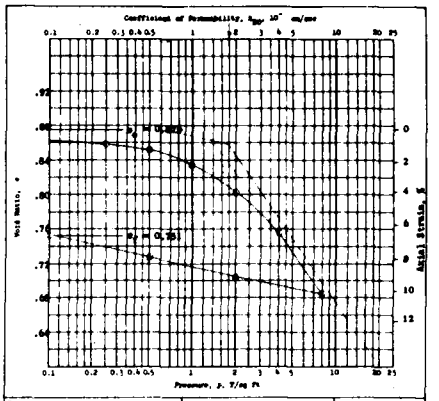
REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

Gray-brown fat clay. Friable. Brittle, blocky structure from center to bottom section of core. Some sample disturbance center down. Calcarious stringers throughout. Considerably more moist from center to top. Medium consistency, impervious. Medium toughness at PL, high gloss shine, no shake reaction. Specimen from upper portion.

PROJECT: MCR-14-75-25-ND-H
Highway No. 5, Road Raise
BORING NO: 74-50M SAMPLE NO: 4
DEPTH: 10.0 - 12.2
MRD LAB NO: 74/342 DATE: JAN 1975

TRIAXIAL COMPRESSION TEST REPORT
FIGURE 5

③

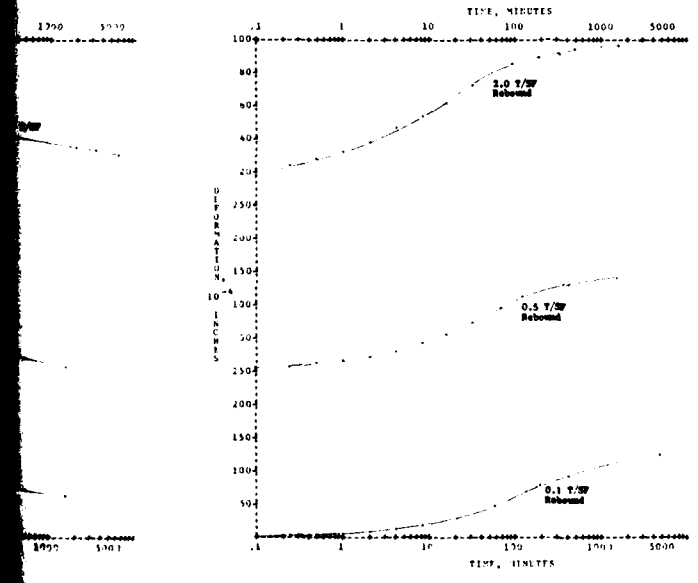


Type of Specimen	Undisturbed	Before Test	After Test
Diam 4.44 in.	Ht 1.00 in.	Water Content, w_o 29.5 %	w_f 26.8 %
Overburden Pressure, p_o T/sq ft		Void Ratio, e_o 0.876	e_f 0.751
Preconsol. Pressure, p_c T/sq ft		Saturation, S_o 93 %	S_f 98 %
Compression Index, C_c		Dry Density, γ_d 91.4 lb/ft³	
Classification Fat clay, CH		k_{90} at e_o = × 10⁻⁷ cm/sec	
LL 57	G_s 2.75	Project MCR-14-75-25-ND-H	
PL 21	D_{10}	MRD Lab. No. 74/342	
Remarks		Area Highway No. 5, Road Raise	
		Boring No. 74-50M	Sample No. 4
		Depth 10.0 - 12.2	Date 17 JAN 1975

CONSOLIDATION TEST REPORT

Figure 7

④



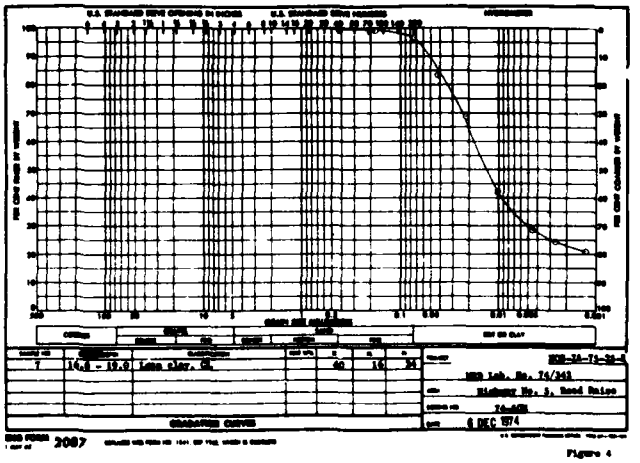
PROJECT: MCR-14-75-25-ND-H
MRD LABORATORY NO: 74/342 Highway No. 5, Road Raise
BORING NO: 74-50M SAMPLE NO: 4 DEPTH: 10.0 - 12.2 DATE: 17 JAN 1975

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

FIGURE 7c

⑦



7	16.8 - 19.0	Lean clay, CL	40	16	24

GRADATION CURVE

MCR-14-75-25-ND-H
MRD Lab. No. 74/342
Highway No. 5, Road Raise
74-50M
6 DEC 1974

ENG FORM 2087

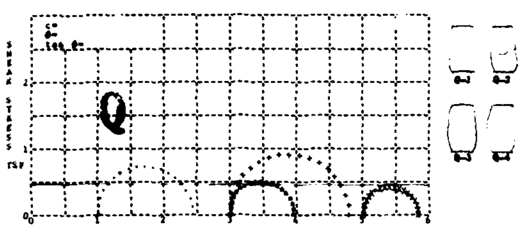
Figure 4

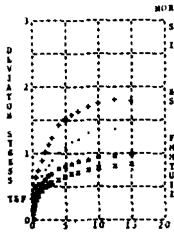
⑤

DESIGN MEMORANDUM NO. 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
SOILS TEST DATA
STATE HIGHWAY NO. 5
BORINGS 74-49M AND 74-50M
ST. PAUL, MINN. DISTRICT
JUNE 1963

RI-R-8/779 PLATE NO. 8-50

CORPS OF ENGINEERS





SPECIMEN NUMBER		1	2	3	4
INITIAL	WATER CONTENT,%	26.1	25.3	27.2	25.9
	DRY DENSITY,PCF	98.6	100.1	97.3	95.3
	SATURATION,%	99	100	100	96
	VOID RATIO	.71	.68	.74	.71
BEFORE SHEAR	WATER CONTENT,%	25.5	25.0	27.6	25.5
	DRY DENSITY,PCF	98.6	101.5	97.0	96.3
	SATURATION,%	97	100+	100+	96
	VOID RATIO	.71	.66	.74	.71
FINAL BACK PRESSURE,TSF		.00	.00	.00	.00
MINOR PRINCIPAL STRESS,TSF		1.00	3.00	5.00	3.00
MAX DEVIATOR STRESS,TSF		1.45	1.61	.65	.97
TIME TO MAX DEV,MIN		30	25	31	23
ULT DEVIATOR STRESS,TSF		1.45	1.79	.35	.97
INITIAL DIAMETER,IN		1.392	1.399	1.432	1.409
INITIAL HEIGHT,IN		2.977	2.960	2.951	2.957

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Lean clay, CL

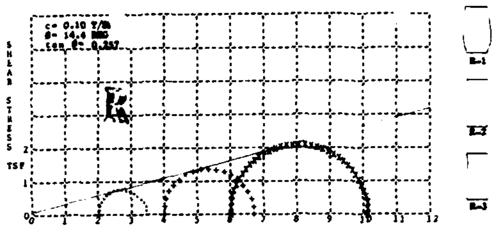
LL 40 PL 16 PI 24 Gs= 2.70 TYPE SPECIMEN: UNDISTURBED TYPE TEST Q

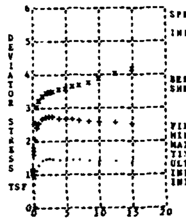
REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

Dark brown lean clay, mottled orange brown and gray. Soft consistency, plastic structure, slightly sensitive. Medium toughness at PL, dull shine, and sluggish shake reaction.

PROJECT: MCS-IA-75-35-ED-R
Highway No. 5, Road Raise
BORING NO: 74-5CN SAMPLE NO: 7
DEPTH: 16.8 - 19.0
MRD LAB NO: 74/342 DATE 6 DEC 1974
TRIAXIAL COMPRESSION TEST REPORT
FIGURE 1

①





SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT,%	29.5	28.8	29.6
	DRY DENSITY,PCF	91.6	93.6	92.0
	SATURATION,%	95	97	96
	VOID RATIO	.84	.80	.83
BEFORE SHEAR	WATER CONTENT,%	28.2	25.8	24.7
	DRY DENSITY,PCF	95.7	99.3	101.1
	SATURATION,%	100+	100+	100+
	VOID RATIO	.76	.70	.67
FINAL BACK PRESSURE,TSF		4.10	4.10	4.10
MINOR PRINCIPAL STRESS,TSF		2.00	4.00	6.00
MAX DEVIATOR STRESS,TSF		1.49	2.73	4.19
TIME TO MAX DEV,MIN		20	22	124
ULT DEVIATOR STRESS,TSF		1.37	2.50	4.19
INITIAL DIAMETER,IN		1.402	1.402	1.398
INITIAL HEIGHT,IN		2.991	2.999	3.005

CONTROLLED-STRAIN TEST

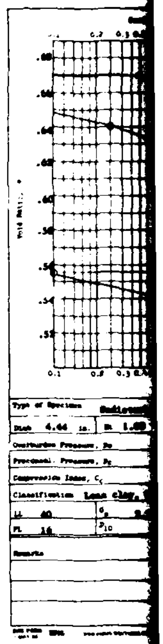
DESCRIPTION OF SPECIMENS: Lean clay, CL

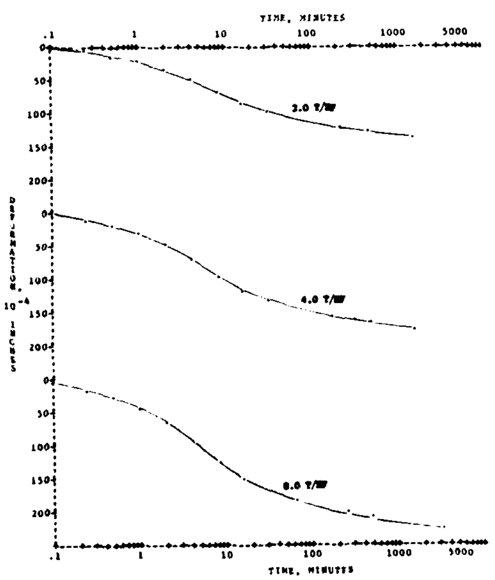
LL 40 PL 16 PI 24 Gs= 2.70 TYPE SPECIMEN: UNDISTURBED TYPE TEST R

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

PROJECT: MCS-IA-75-35-ED-R
Highway No. 5, Road Raise
BORING NO: 74-5CN SAMPLE NO: 7
DEPTH: 16.8 - 19.0
MRD LAB NO: 74/342 DATE 6 DEC 1974
TRIAXIAL COMPRESSION TEST RE
FIGURE 2

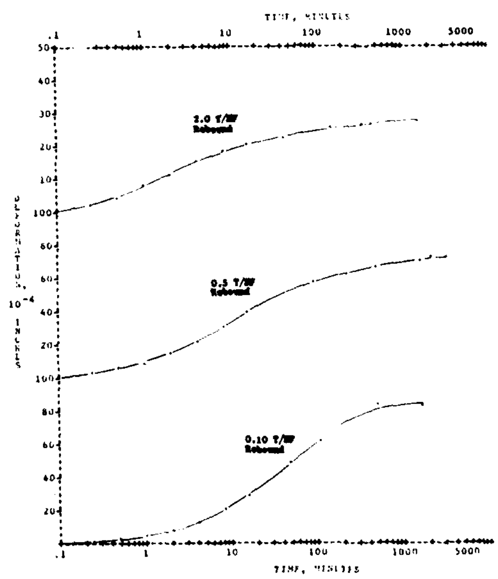
②





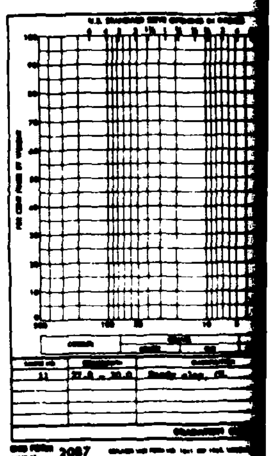
PROJECT: MCS-IA-75-35-ED-R
MRD LABORATORY NO: 74/342 Highway No. 5, Road Raise
BORING NO: 74-5CN SAMPLE NO: 7 DEPTH: 16.8 - 19.0 DATE: 6 DEC 1974
CONSOLIDATION TEST -- TIME CURVES
MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088
FIGURE 3b

⑤

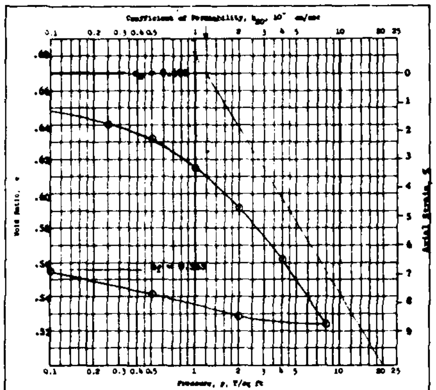


PROJECT: MCS-IA-75-35-ED-R
MRD LABORATORY NO: 74/342 Highway No. 5, Road Raise
BORING NO: 74-5CN SAMPLE NO: 7 DEPTH: 16.8 - 19.0 DATE: 6 DEC 1974
CONSOLIDATION TEST -- TIME CURVES
MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088
FIGURE 3c

⑥



2087



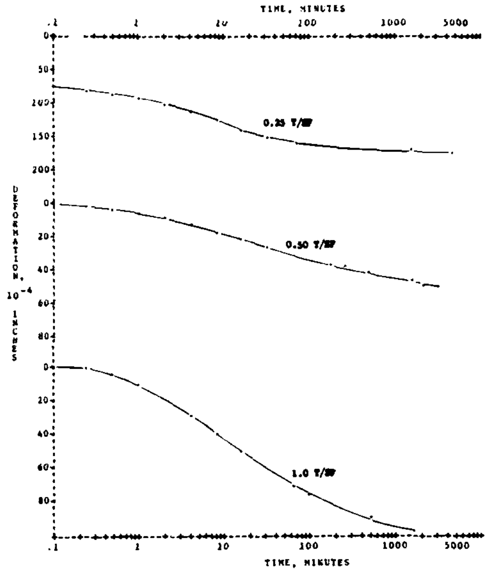
Type of Specimen	Undisturbed	Before Test			After Test	
Diam 4.44 in.	Ht 1.00 in.	Water Content, w_o	24.7 %	w_f	20.7 %	
Overburden Pressure, p_o	T/sq ft	Void Ratio, e_o	0.670	e_f	0.555	
Preconsol. Pressure, p_c	T/sq ft	Saturation, S_o	100 %	S_f	100+ %	
Compression Index, C_c		Dry Density, γ_d	100.9 lb/ft³			
Classification	Loam clay, CL	k_{20} at e_o =	× 10⁻ cm/sec			
LL 40	G_s 2.70	Project	NCS-IA-73-35-ED-8			
PL 16	D_{10}		MRD Lab. No. 74/342			
Remarks		Area	Highway No. 5, Road Raise			
		Boring No. 74-50M	Sample No. 7			
		Depth 16.8 - 19.0	Date 6 DEC 1974			

CONSOLIDATION TEST REPORT

ENG FORM 2088

Figure 3

③



PROJECT: NCS-IA-73-35-ED-8

MRD LABORATORY NO: 74/342 Highway No. 5, Road Raise

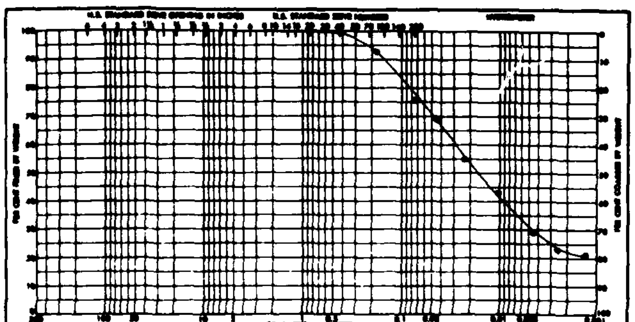
BORING NO: 74-50M SAMPLE NO: 7 DEPTH: 16.8 - 19.0 DATE: 6 DEC 1974

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

FIGURE 3a

④



Sample No.	Elev or Depth	Classification	Nat W%	LL	PL	PI
11	27.8 - 30.0	Sandy clay, CL		46	[illegible]	[illegible]

Project: NCS-IA-73-35-ED-8 MRD Lab. No. 74/342

Boring No. 74-50M

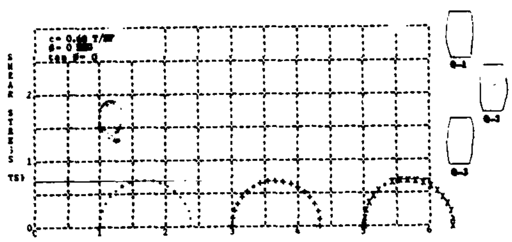
Date 18 DEC 1974

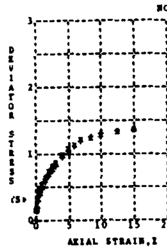
GRADATION CURVES

ENG FORM 2087

Figure 4

⑦





SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT,%	27.8	29.7	29.3
	DRY DENSITY,PCF	95.0	92.4	92.6
	SATURATION,%	97	98	97
	VOID RATIO	.77	.82	.81
BEFORE SHEAR	WATER CONTENT,%	27.6	29.5	29.2
	DRY DENSITY,PCF	95.5	92.5	92.9
	SATURATION,%	98	97	97
	VOID RATIO	.76	.82	.81
FINAL BACK PRESSURE,TSF		.00	.00	.00
MINOR PRINCIPAL STRESS,TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS,TSF		1.39	1.35	1.37
TIME TO MAX DEV,MIN		31	31	31
ULT DEVIATOR STRESS,TSF		1.39	1.35	1.37
INITIAL DIAMETER,IN		1.409	1.407	1.413
INITIAL HEIGHT,IN		2.944	2.960	2.942

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

LL 46 PL 20 PI 26 Gs= 2.69 TYPE SPECIMEN: UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

Torvane = 0.50 T/SF
Dark gray sandy clay, fine sand, brittle structure, medium consistency, insensitive. Medium toughness at PL, dull shine, sluggish shake reaction. Some small decayed sticks and/or roots (.2 inch max). Few small shells near bottom.

PROJECT: NCS-IA-73-35-ED-8
Highway No. 5, Road Raise
BORING NO: 74-50M SAMPLE NO: 11
DEPTH: 27.8 - 30.0
MRD LAB NO: 74/342 DATE 18 DEC 1974

TRIAXIAL COMPRESSION TEST REPORT
FIGURE 1

⑧

DESIGN MEMORANDUM NO. 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

SOILS TEST DATA
STATE HIGHWAY NO. 5

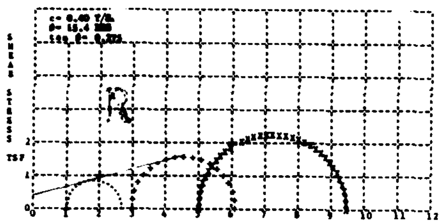
BORING 74-50M

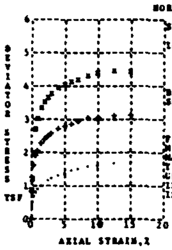
ST. PAUL, MINN. DISTRICT

JUNE 1983

1 2

CORPS OF ENGINEERS





SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT,%	32.8	31.7	31.3
	DRY DENSITY,PCF	88.2	89.7	91.2
	SATURATION,%	98	98	100+
	VOID RATIO	.90	.87	.84
BEFORE SHEAR	WATER CONTENT,%	30.0	25.5	23.1
	DRY DENSITY,PCF	92.4	99.1	103.2
	SATURATION,%	99	99	99
	VOID RATIO	.82	.69	.63
FINAL BACK PRESSURE,TSF		2.60	2.60	2.60
MINOR PRINCIPAL STRESS,TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS,TSF		1.69	3.15	4.49
TIME TO MAX DEV,MIN		120	121	104
ULT DEVIATOR STRESS,TSF		1.69	3.15	4.46
INITIAL DIAMETER,IN		1.397	1.405	1.401
INITIAL HEIGHT,IN		2.994	2.992	2.991

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

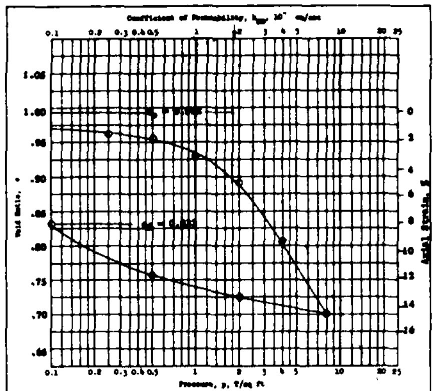
LL 46 PL 20 PI 26 Gs= 2.69 TYPE SPECIMEN: UNDISTURBED TYPE TEST R

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

PROJECT: [illegible]
Highway No. 5, Road Raise
BORING NO: 74-6UN SAMPLE NO: 11
DEPTH: 27.0 - 30.0
MRD LAB NO 74/342 DATE 18 DEC 1974

TRIAXIAL COMPRESSION TEST REPORT
FIGURE 2

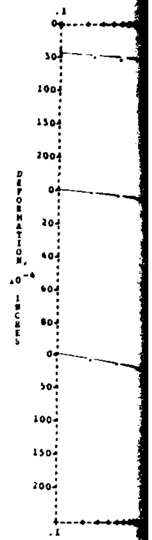
①

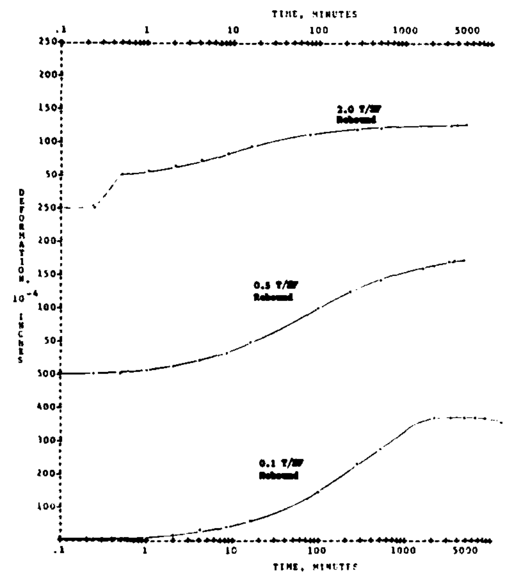


Type of Specimen	Undisturbed	Before Test		After Test	
Diam 4.25 in.	Ht 1.00 in.	Water Content, w_o	30.7 %	w_f	33.4 %
Overburden Pressure, p_o T/sq ft		Void Ratio, e_o	0.992	e_f	0.832
Preconsol. Pressure, p_c T/sq ft		Saturation, S_o	83 %	S_f	100+ %
Compression Index, C_c		Dry Density, γ_d	84.2 lb/ft³		
Classification	Sandy clay, CL	k_{20} at e_o = x 10⁻ cm/sec			
LL 46	G_s 2.69	Project	[illegible]		
PL 20	D_{10}	MRD Lab. No. 74/342			
Remarks		Area	Highway No. 5, Road Raise		
		Boring No. 74-6UN	Sample No. 11		
		Depth 27.0 - 30.0	Date 18 DEC 1974		
		CONSOLIDATION TEST REPORT			

Figure 3

②





PROJECT: [illegible]
MRD LABORATORY NO: 74/342 Highway No. 5, Road Raise
BORING NO: 74-6UN SAMPLE NO: 11 DEPTH: 27.0 - 30.0 DATE: 18 DEC 1974
CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088 FIGURE 3a

⑤

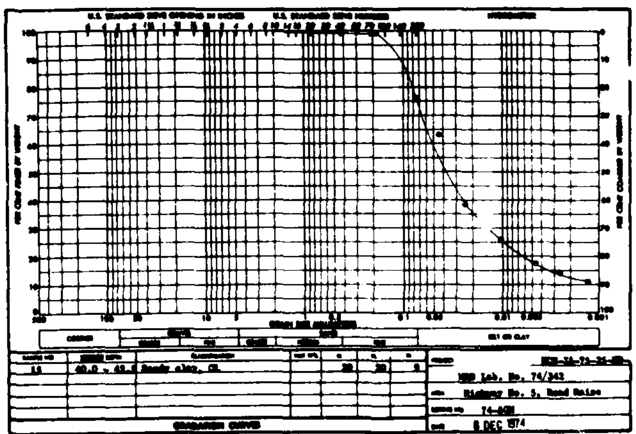
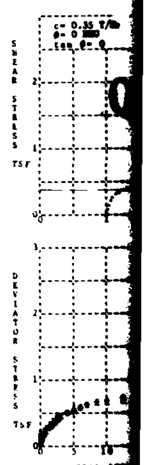
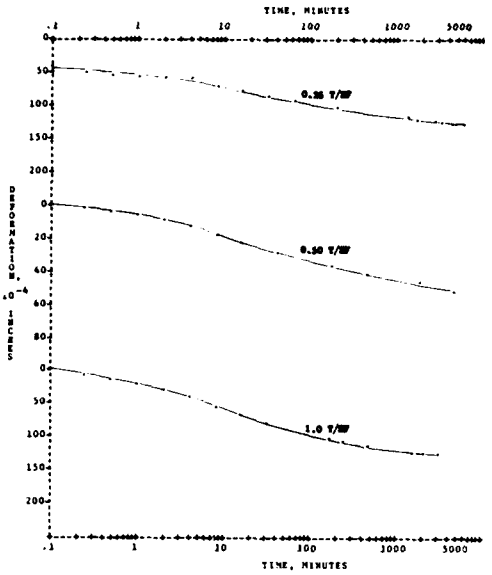


Figure 8

⑥





PROJECT: [redacted]

MRD LABORATORY NO: 74/362 Highway No. 5, Sand Coulee

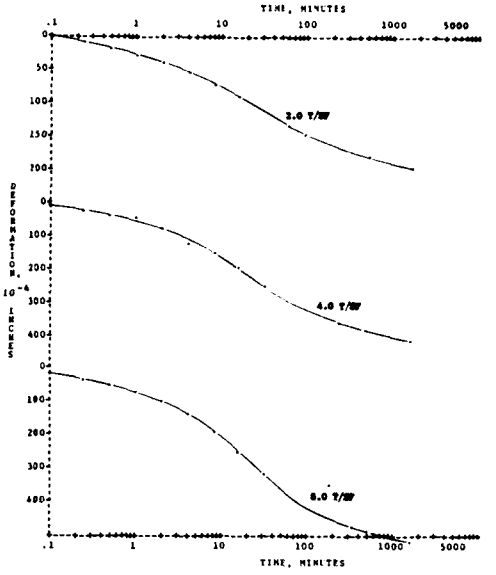
BORING NO: 74-50M SAMPLE NO: 11 DEPTH: 27.0 - 30.0 DATE: 18 DEC 1974

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

FIGURE 3a

③



PROJECT: [redacted]

MRD LABORATORY NO: 74/362 Highway No. 5, Sand Coulee

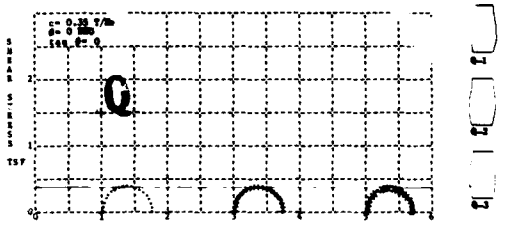
BORING NO: 74-50M SAMPLE NO: 11 DEPTH: 27.0 - 30.0 DATE: 18 DEC 1974

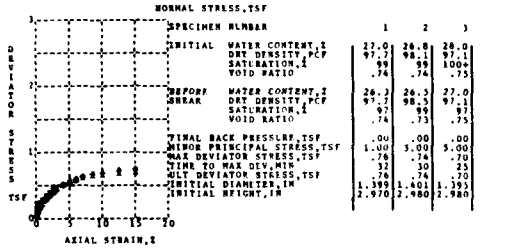
CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

FIGURE 3b

④





SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT, %	27.0	26.8	28.0
	DRY DENSITY, PCF	97.7	98.1	97.1
	SATURATION, %	99	99	100+
	VOID RATIO	.74	.74	.75
BEFORE SHEAR	WATER CONTENT, %	26.3	26.3	27.0
	DRY DENSITY, PCF	97.7	98.5	97.1
	SATURATION, %	97	99	97
	VOID RATIO	.74	.73	.75
FINAL BACK PRESSURE, TSF		.00	.00	.00
MINOR PRINCIPAL STRESS, TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS, TSF		.76	.74	.70
TIME TO MAX DEV, MIN		32	30	25
ULT DEVIATOR STRESS, TSF		.76	.74	.70
INITIAL DIAMETER, IN		1.399	1.401	1.391
INITIAL HEIGHT, IN		2.970	2.980	2.980

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

LL 39 PL 20 PI 19 Gs= 2.73 TYPE SPECIMEN: UNDISTURBED TYPE TEST Q

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

Silty sandy clay, gray. Soft consistency, brittle structure, slightly sensitive. Low toughness at PL, dull shine, fast shake reaction.

PROJECT: [redacted]
Highway No. 5, Sand Coulee

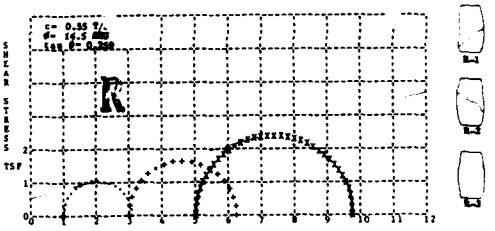
BORING NO: 74-50M SAMPLE NO: 15

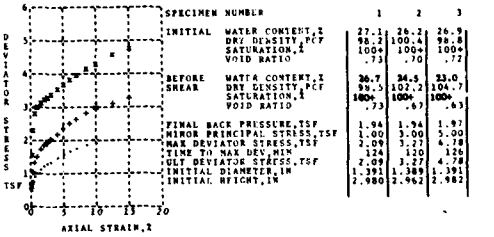
DEPTH: 40.0 - 42.5

MRD LAB NO: 74/362 DATE 6 DEC 1974

TRIAXIAL COMPRESSION TEST REPORT
FIGURE 5

⑦





SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT, %	27.1	26.2	26.9
	DRY DENSITY, PCF	98.2	100.4	98.8
	SATURATION, %	100+	100+	100+
	VOID RATIO	.73	.70	.72
BEFORE SHEAR	WATER CONTENT, %	26.7	24.5	23.0
	DRY DENSITY, PCF	99.5	102.2	104.7
	SATURATION, %	100+	100+	100+
	VOID RATIO	.73	.67	.63
FINAL BACK PRESSURE, TSF		1.94	1.94	1.97
MINOR PRINCIPAL STRESS, TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS, TSF		2.09	3.27	4.78
TIME TO MAX DEV, MIN		124	120	126
ULT DEVIATOR STRESS, TSF		2.09	3.27	4.78
INITIAL DIAMETER, IN		1.391	1.389	1.391
INITIAL HEIGHT, IN		2.980	2.962	2.982

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Sandy clay, CL

LL 39 PL 20 PI 19 Gs= 2.73 TYPE SPECIMEN: UNDISTURBED TYPE TEST R

REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089

PROJECT: [redacted]
Highway No. 5, Sand Coulee

BORING NO: 74-50M SAMPLE NO: 15

DEPTH: 40.0 - 42.5

MRD LAB NO: 74/362 DATE 6 DEC 1974

TRIAXIAL COMPRESSION TEST REPORT
FIGURE 6

⑧

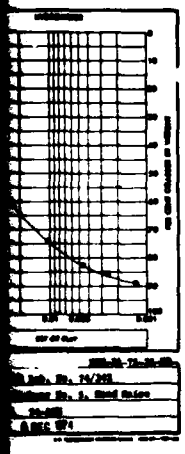


Figure 4

DESIGN MEMORANDUM NO. 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

SOILS TEST DATA
STATE HIGHWAY NO. 5

BORING 74-50M

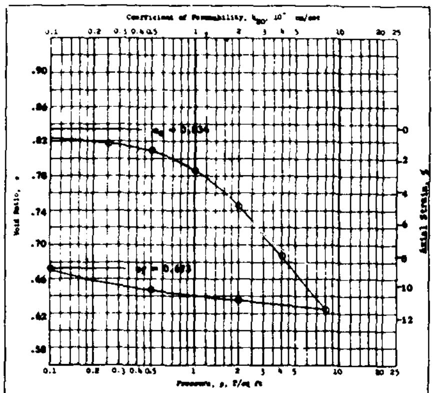
ST PAUL, MINN. DISTRICT

JUNE 1983

RI-R-S/781

PLATE NO. 6-62

CORPS OF ENGINEERS

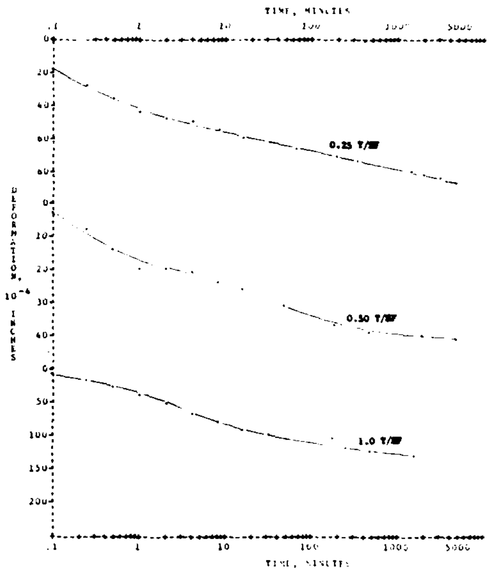


Type of Specimen: Undisturbed		Before Test			After Test	
Diam 4.28 in.	Ht 1.00 in.	Water Content, w_0	29.2 %	w_f	23.2 %	
Overburden Pressure, p_0 T/sq ft		Void Ratio, e_0	0.834	e_f	0.673	
Preconsol. Pressure, p_c T/sq ft		Saturation, S_0	96 %	S_f	100 %	
Compression Index, C_c		Dry Density, γ_d	92.9 lb/ft³			
Classification Sandy clay, CL		k_{20} at e_0 = $\times 10^{-}$ cm/sec				
LL 39	G_s 2.73	Project NCB-IA-75-35-ED-R				
PL 20	D_{10}	NED Lab. No. 74/342				
Remarks		Area Highway No. 5, Road Raise				
		Boring No. 74-50M		Sample No. 15		
		Depth 40.0 - 42.5		Date 6 DEC 1974		
		CONSOLIDATION TEST REPORT				

ENG FORM 2088 — PREVIOUS EDITIONS ARE OBSOLETE

Figure 7

①

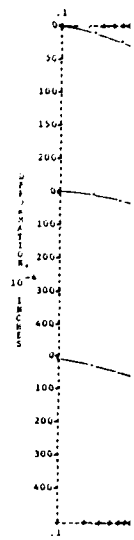


PROJECT: NCB-IA-75-35-ED-R
NED LABORATORY NO: 74/342 Highway No. 5, Road Raise
BORING NO: 74-50M SAMPLE NO: 15 DEPTH: 40.0 - 42.5 DATE: 6 DEC 1974
CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

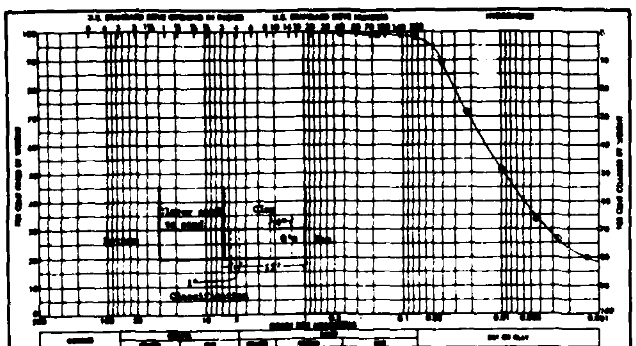
FIGURE 7A

②



PROJECT:
NED LABORATORY NO.
BORING NO: 74-50M

MACHINE PRINT OUT
FORMAT AFTER ENG



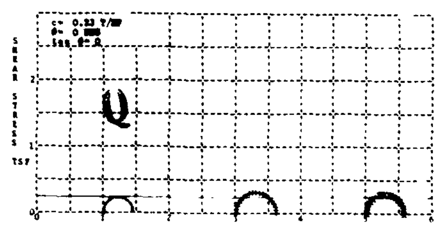
Boring No.	Elev or Depth	Classification	Nat W%	LL	PL	PI
16	47.5 - 50.0	Lean clay, CL		45	18	27

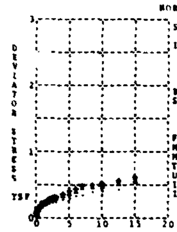
Project NCB-IA-75-35-ED-R
NED Lab. No. 74/342
Area Highway #5, Road Raise
Boring No. 74-50M
Date 18 DEC 1974
GRADATION CURVES

ENG FORM 2087

Figure 8

⑤





SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT,%	33.0	32.0	33.5
	DRY DENSITY,PCF	89.2	91.1	89.0
	SATURATION,%	100+	100+	100+
	VOID RATIO	.89	.85	.89
BEFORE SHEAR	WATER CONTENT,%	32.7	31.5	33.1
	DRY DENSITY,PCF	89.6	91.1	89.0
	SATURATION,%	100+	100+	100
	VOID RATIO	.88	.85	.89
FINAL BACK PRESSURE,TSF		.00	.00	.00
MINOR PRINCIPAL STRESS,TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS,TSF		.45	.62	.58
TIME TO MAX DEV,MIN		30	31	30
ULT DEVIATOR STRESS,TSF		.45	.62	.58
INITIAL DIAMETER,IN		1.388	1.415	1.407
INITIAL HEIGHT,IN		2.989	2.909	2.943

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: Lean clay, CL

LL 45 PL 18 PI 27 Gs= 2.70 TYPE SPECIMEN: UNDISTURBED TYPE TEST Q

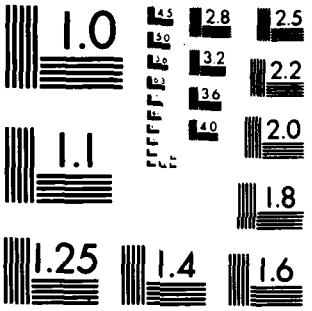
REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089
Torvane = 0.32 T/SF
Dark grey lean clay. Brittle structure, soft consistency, insensitive. Medium strength at PL, no shine, no shake reaction. Slight organic odor.

PROJECT: NCB-IA-75-35-ED-R
Highway No. 5, Road Raise
BORING NO: 74-50M SAMPLE NO: 16
DEPTH: 47.5 - 50.0
NED LAB NO: 74/342 DATE 18 DEC 1974
TRIAXIAL COMPRESSION TEST REPORT
FIGURE 9

⑥

AD-A136 229 LAKE DARLING FLOOD CONTROL PROJECT SOURIS RIVER NORTH DAKOTA GENERAL PROJ..(U) CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT JUN 83 3/3

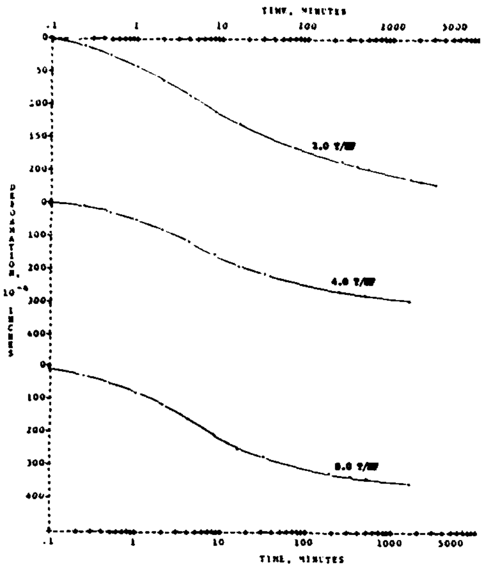
UNCLASSIFIED F/G 8/7 NL



DATE: 6 DEC 1974

CURVES

FIGURE 7a



PROJECT:

MRD LABORATORY NO: 74/342 Highway No. 5, Road Raise

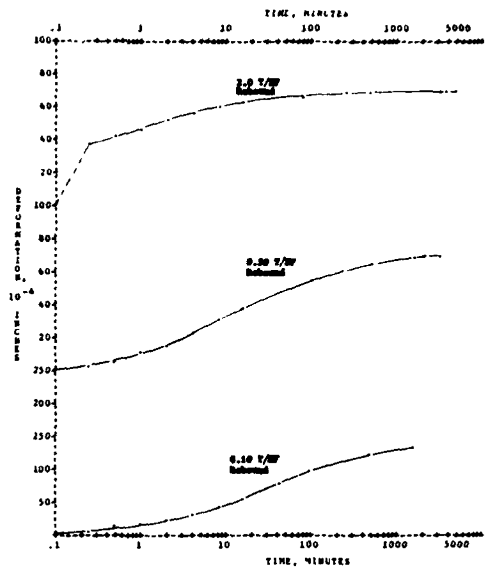
BORING NO: 74-50M SAMPLE NO: 15 DEPTH: 40.0 - 42.5 DATE: 6 DEC 1974

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

FIGURE 7b

③



PROJECT:

MRD LABORATORY NO: 74/342 Highway No. 5, Road Raise

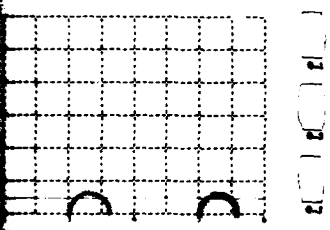
BORING NO: 74-50M SAMPLE NO: 15 DEPTH: 40.0 - 42.5 DATE: 6 DEC 1974

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

FIGURE 7c

④



SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT,%	33.0	32.0	33.5
	DRY DENSITY,PCF	89.2	91.1	89.0
	SATURATION,%	100+	100+	100+
	VOID RATIO	.89	.85	.89
BEFORE SHEAR	WATER CONTENT,%	32.7	31.5	33.1
	DRY DENSITY,PCF	89.6	91.1	89.0
	SATURATION,%	100+	100+	100
	VOID RATIO	.88	.85	.89
FINAL BACK PRESSURE,TSF		.00	.00	.00
MINOR PRINCIPAL STRESS,TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS,TSF		.65	.62	.58
TIME TO MAX DEV,MIN		30	31	30
ULT DEVIATOR STRESS,TSF		.65	.62	.58
INITIAL DIAMETER,IN		1.388	1.415	1.407
INITIAL HEIGHT,IN		2.989	2.909	2.941

SPECIMENS: Lean clay, CL

Gs= 2.70 TYPE SPECIMEN: UNDISTURBED TYPE TEST Q

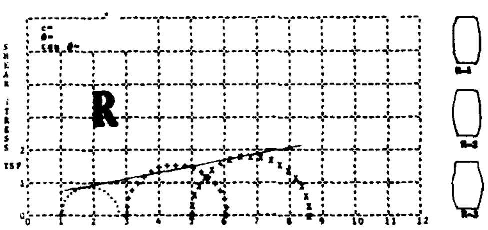
OUT
2089

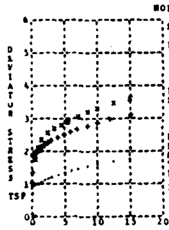
structure,
Random
to choke
clay.

PROJECT:
Highway No. 5, Road Raise
BORING NO: 74-50M SAMPLE NO: 16
DEPTH: 47.5 - 50.0
MRD LAB NO: 74/342 DATE 18 DEC 1974

TRIAXIAL COMPRESSION TEST REPORT
FIGURE 5

⑥





CONTROLLED-STRAIN TEST

SPECIMEN NUMBER		1	2	3
INITIAL	WATER CONTENT,%	29.3	28.0	29.2
	DRY DENSITY,PCF	93.7	95.8	94.3
	SATURATION,%	99	100	100+
	VOID RATIO	.80	.76	.79
BEFORE SHEAR	WATER CONTENT,%	25.3	23.7	21.5
	DRY DENSITY,PCF	98.5	104.9	105.8
	SATURATION,%	96	100+	98
	VOID RATIO	.71	.61	.59
FINAL BACK PRESSURE,TSF		2.60	2.60	2.60
MINOR PRINCIPAL STRESS,TSF		1.00	3.00	5.00
MAX DEVIATOR STRESS,TSF		1.77	3.11	3.63
TIME TO MAX DEV,MIN		117	117	130
ULT DEVIATOR STRESS,TSF		1.77	3.11	3.63
INITIAL DIAMETER,IN		1.397	1.392	1.397
INITIAL HEIGHT,IN		3.004	2.996	3.001

DESCRIPTION OF SPECIMENS: Lean clay, CL

LL 46 PL 18 PI 27 Gs= 2.70 TYPE SPECIMEN: UNDISTURBED TYPE TEST R

*REMARKS: MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2089*

PROJECT:
Highway No. 5, Road Raise
BORING NO: 74-50M SAMPLE NO: 16
DEPTH: 47.5 - 50.0
MRD LAB NO: 74/342 DATE 18 DEC 1974

TRIAXIAL COMPRESSION TEST REPORT
FIGURE 6

⑦

DESIGN MEMORANDUM NO. 3 GENERAL

FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA

SOILS TEST DATA
STATE HIGHWAY NO. 5

BORING 74-50M

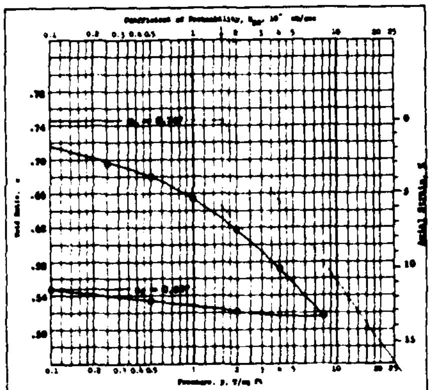
ST. PAUL, MINN. DISTRICT

JUNE 1983

RI - R - S/782

PLATE NO. B-83

CORPS OF ENGINEERS

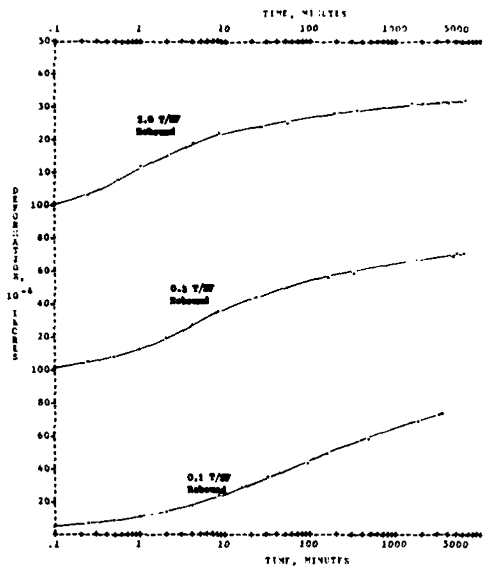


Type of Specimen [illegible]	
[illegible] 4.25 in.	[illegible] 1.00 in.
Classification [illegible] clay, CL	
LL [illegible]	G_s 2.7[illegible]
PL [illegible]	
Project [illegible]	
[illegible] Lab. No. 74/342	
Boring No. 74-[illegible]	Sample No. 10
Depth 47.5 - [illegible]	Date 1[illegible] DEC 1974

CONSOLIDATION TEST REPORT

Figure 7

①



PROJECT: [illegible]

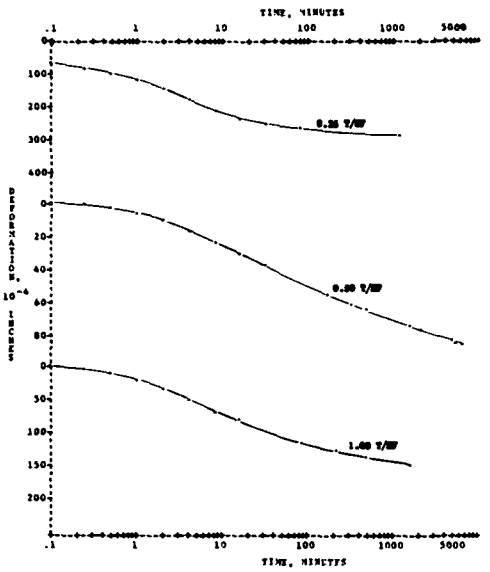
MRD LABORATORY NO: 74/342

BORING NO: 74-[illegible] SAMPLE NO: 10 DEPTH: 47.5 - 50.0 DATE: 18 DEC 1974

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088 FIGURE 7c

②



PROJECT: [redacted]

MRD LABORATORY NO: 74/348

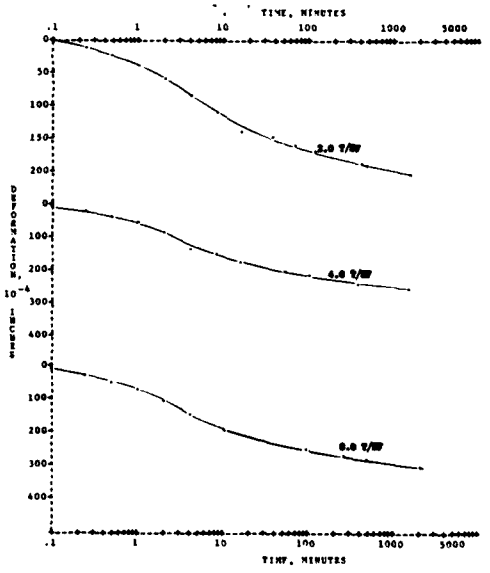
BORING NO: 74-[redacted] SAMPLE NO: 18 DEPTH: 47.5 - 50.0 DATE: 18 DEC 1974

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

FIGURE 7a

②



PROJECT: [redacted]

MRD LABORATORY NO: 74/348

BORING NO: 74-[redacted] SAMPLE NO: 18 DEPTH: 47.5 - 50.0 DATE: 18 DEC 1974

CONSOLIDATION TEST -- TIME CURVES

MACHINE PRINT OUT
FORMAT AFTER ENG FORM 2088

FIGURE 7b

④

DESIGN MEMORANDUM NO. 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
SOILS TEST DATA
STATE HIGHWAY NO. 5
BORING 74-50M
ST PAUL, MINN. DISTRICT
JUNE 1975

RI-R-8/783

PLATE NO. 8-84

1 2